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A Study of Ventilator Malfunction in Six Common Ventilators

Impact of a Standardized Protocol for Placement of Indwelling Arterial Catheters

SPECIAL ARTICLES

Analysis of Failure Time Data

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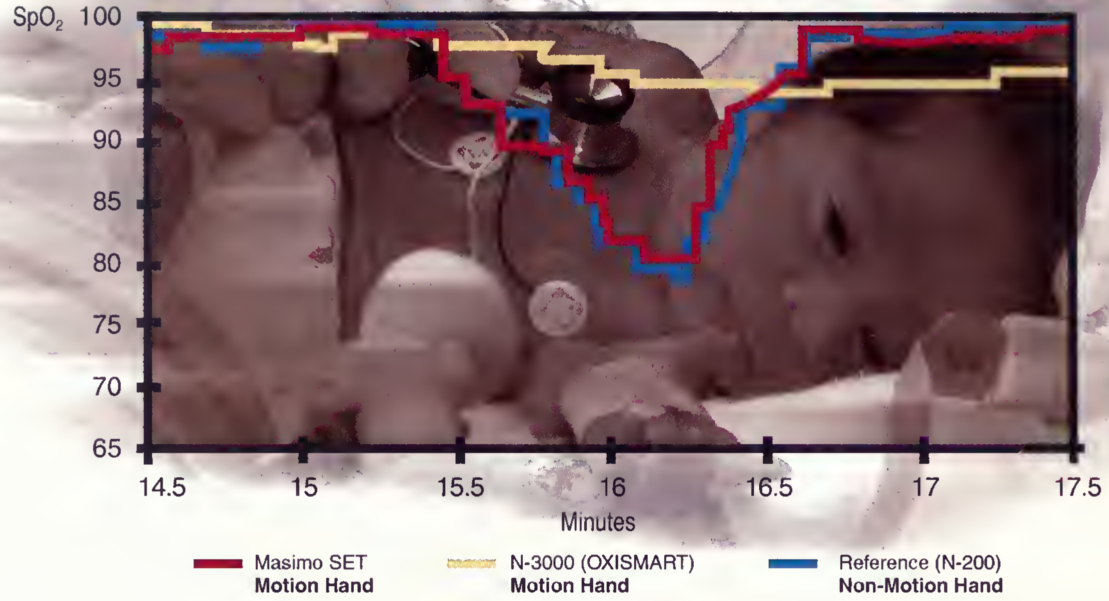

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Source: Barker SJ, Shah NK. The Effects of Motion on the Performance of Pulse Oximeters in Volunteers. *Anesthesiology* 1997;86(1):101-108.

low perfusion study

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Source: Barker SJ, Novak S, Morgan S. The Performance of Three Pulse Oximeters During Low Perfusion in Volunteers. *Anesthesiology* 1997;87(3A):A409.

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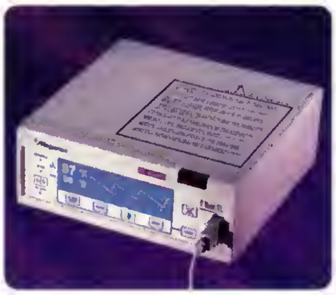

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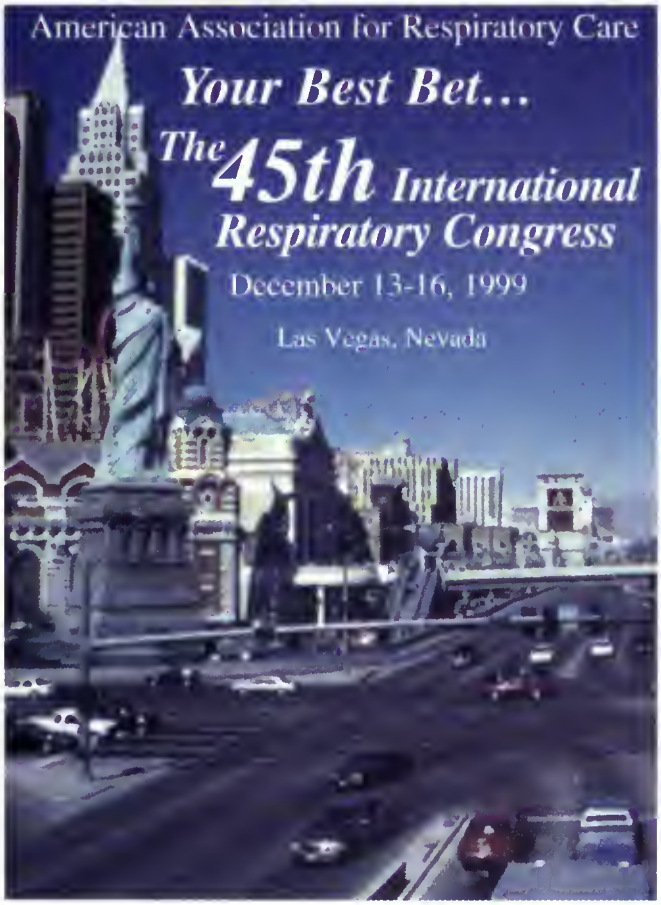

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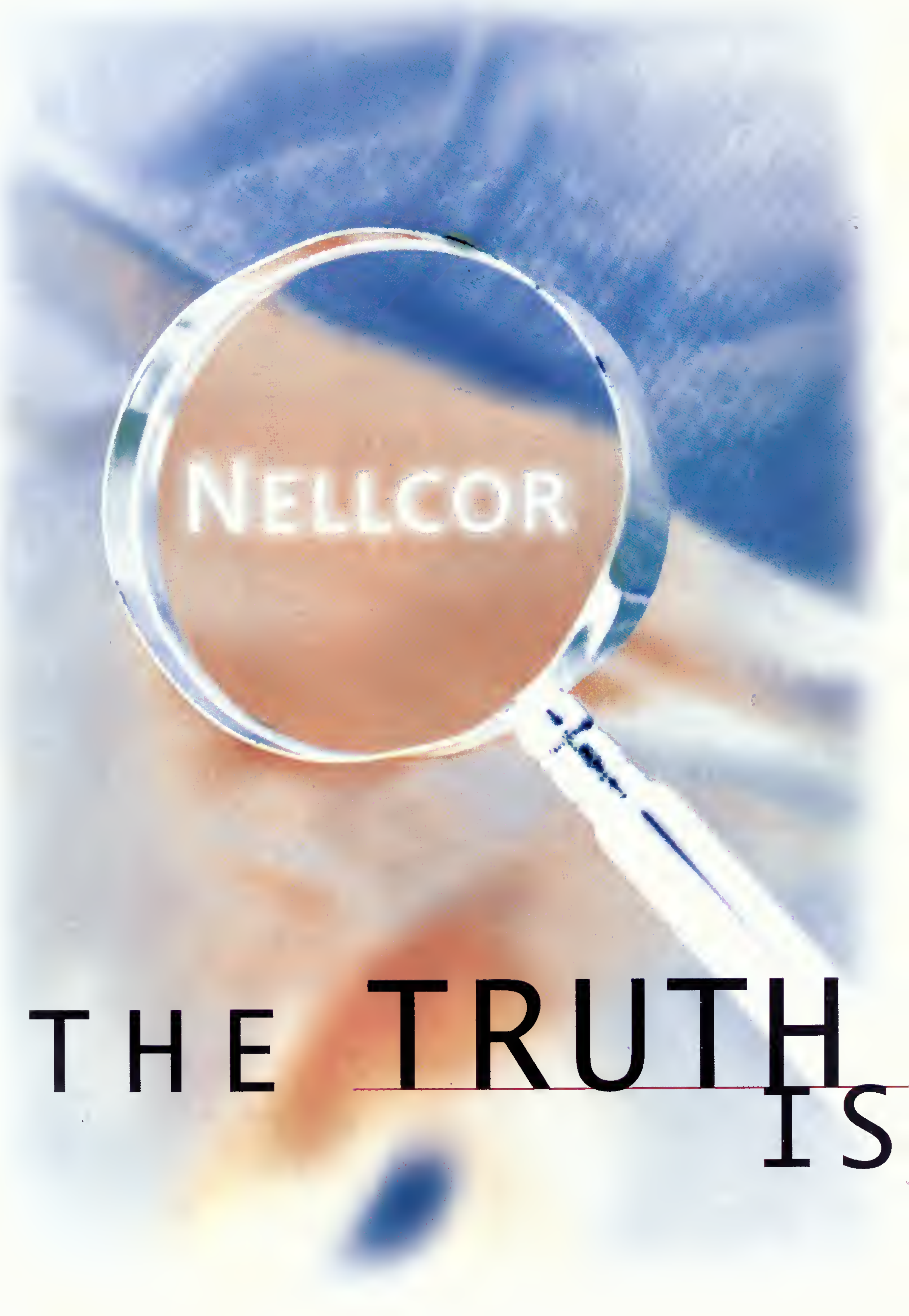

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The Relation Between Physician Experience and Patterns of Care for Patients with AIDS-Related *Pneumocystis Carinii* Pneumonia: Results from a Survey of 1,500 Physicians in the United States—Bach PB, Calhoun EA, Bennett CL. Chest 1999 Jun;115(6):1563-1569.

STUDY OBJECTIVES: To determine whether physician experience and specialty influence the approach to care of AIDS patients with pneumonia, we surveyed physicians about their management of possible *Pneumocystis carinii* pneumonia (PCP) infection. DESIGN, SETTING, PARTICIPANTS: A postal survey was sent to a random sample of 1,500 internists and family physicians in the United States drawn from the American Medical Association master file who were identified by a pharmaceutical marketing company as having written prescriptions for AIDS-related agents in the previous year. MEASUREMENTS AND RESULTS: The survey had a 53% response rate. Physicians more experienced in AIDS care were more likely to advocate diagnostic bronchoscopy over initiation of empiric anti-PCP therapy for HIV-infected patients with undiagnosed pulmonary infiltrates (odds ratio [OR], 1.4 for a patient with mild severity of illness [$p = 0.02$]; OR, 1.7 for a severely ill patient [$p < 0.001$]). Physician specialty and fee-for-service reimbursement were independently associated with higher rates of bronchoscopy, with internists favoring bronchoscopy more frequently than family physicians. High-experience providers and internists also predicted better clinical outcomes for the hypothetical patients. CONCLUSIONS: Our findings extend the observations about HIV experience and PCP prophylaxis to the setting of diagnosis and treatment. Physicians with higher levels of experience with AIDS, internists, and physicians reimbursed as fee-for-service providers are more likely to support diagnostic confirmation of PCP than empiric treatment approaches.

Percutaneous Dilation of Tracheal Stenosis—Susanto I. Chest 1999 Jun;115(6):1751-1752.

A high-grade complex tracheal stenosis distal to a tracheostomy tube occurred in a patient with a chronic vegetative state. The stenosis was easily and rapidly dilated at bedside using commercially available percutaneous tracheostomy kit dilators. Following tracheal dilation, a larger tracheostomy tube was inserted, resulting in the splinting of the stenotic area. To my knowledge, this is the first report of such a bedside technique for the dilation of a tracheal stenosis through a tracheostomy. This technique may provide a temporary relief from tracheal obstruction as long as the stenosis is within the reach of the dilator.

Effects of Leisure-Time Physical Activity and Ventilatory Function on Risk for Stroke in Men: The Reykjavik Study—Agnarsson U, Thorgeirsson G, Sigvaldason H, Sigfusson N. Ann Intern Med 1999 Jun 15;130(12):987-990.

BACKGROUND: Stroke is a major cause of illness, death, and health expenditures. Leisure-time physical activity may reduce the risk for stroke. OBJECTIVE: To examine the association of leisure-time physical activity and pulmonary function with risk for stroke. DESIGN: Prospective cohort study. SETTING: Reykjavik, Iceland. PARTICIPANTS: 4484 men 45 to 80 years of age followed for a mean (±SD) of 10.6 ± 3.6 years. MEASUREMENTS: Patients underwent physical examination, blood sampling, and spirometry and completed a questionnaire about health and exercise. Computerized hospital records were used to identify strokes, and the Icelandic National Registry was used to identify deaths. RESULTS: New stroke developed in 249 men (5.6%) (hemorrhagic stroke in 44 [18%] and ischemic stroke in 205 [82%]). In a multivariable hazard analysis that controlled for known risk factors for cerebrovascular disease, leisure-time physical activity maintained after 40 years of age was associated with a reduced risk for stroke (relative risk, 0.69 [CI, 0.47 to 1.01] for total stroke and 0.62 [CI, 0.40 to 0.97]] for ischemic stroke). Risk for stroke increased with diminished ventilatory function (FVC or FEV$_1$) (relative risk, 1.9 [CI, 1.06 to 3.25] for the lowest compared with the highest quintile). CONCLUSION: Middle-aged men who participate in leisure-time physical activity and have good pulmonary function seem to have a lower risk for stroke than men who are not active or have diminished pulmonary function.

Effect of Nasogastric Tube Size on Gastroesophageal Reflux and Microaspiration in Intubated Patients—Ferrer M, Bauer TT, Torres A, Hernandez C, Piera C. Ann Intern Med 1999 Jun 15;130(12):991-994.

BACKGROUND: Little evidence exists to support the theory that small-bore nasogastric tubes prevent gastroesophageal reflux and microaspiration in intubated patients. OBJECTIVE: To determine whether gastroesophageal reflux and microaspiration in intubated patients can be reduced by the use of a small-bore nasogastric tube. DESIGN: Randomized, two-period crossover trial. SETTING: Respiratory intensive care unit of a university hospital. PATIENTS: 17 patients intubated for more than 72 hours. INTERVENTIONS: Radioactive technetium colloid was instilled in each patient's stomach. Patients were studied with two nasogastric tubes (one tube with a 6.0-mm external bore and one tube with a 2.85-mm external bore) in randomized order; measurements of radioactive counts with the alternate size of nasogastric tube were repeated 72 hours after original measurements were taken. Sequential samples of serum, gastric juice, and pharyngeal and tracheal secretions were obtained. MEASUREMENTS: Comparison of the time course of radioactive counting in all samples (obtained during the use of each nasogastric tube size in each patient). RESULTS: The mean radioactive count of pharyngeal aspirates ($p = 0.004$) was greater than the baseline count at all time points, as was the cumulative radioactive count of pharyngeal aspirates 17 hours after the first dose of technetium colloid was administered ($p = 0.001$); however, the count of tracheal aspirates was never greater than the count at baseline. No differences were found between tube types when the time course and cumulative counts of pharyngeal and tracheal samples were compared. CONCLUSION: Small-bore nasogastric tubes in intubated patients do not reduce gastroesophageal reflux or microaspiration.

Long-Term Effect of Inhaled Budesonide in Mild and Moderate Chronic Obstructive Pulmonary Disease: A Randomised Controlled Trial—Vestbo J, Sorensen T, Lange P, Brix A, Torre P, Viskum K. Lancet 1999 May 29; 353(9167):1819-1823.

BACKGROUND: Little is known about the long-term efficacy of inhaled corticosteroids in chronic obstructive pulmonary disease (COPD). We investigated the efficacy of inhaled budesonide on decline in lung function and respiratory symptoms in a 3-year placebo-controlled study of patients with COPD. METHODS: We used a parallel-group, randomised, double-blind, placebo-controlled design in a singlecentre study, nested in a continuing epidemiological survey (the Copenhagen City Heart Study). Inclusion criteria were as follows: no asthma; a ratio of forced expiratory volume in 1 s (FEV$_1$) and vital capacity of 0.7 or less; FEV$_1$ which showed no response (<15% change) to 1 mg inhaled terbutaline or prednisolone 37.5 mg orally once daily for 10 days. 290 patients were randomly assigned budesonide, 800 microg plus 400 microg daily for 6 months followed by 400 microg twice daily for 30 months, or placebo for 36 months. The mean age of the participants was 59 years and the mean FEV$_1$ 2.37 L or 86% of predicted. The main outcome measure was rate of FEV$_1$ decline. Analyses were by intention to treat. FINDINGS: The crude rates of FEV$_1$ decline were slightly smaller than expected (placebo group 41.8 mL per year, budesonide group 45.1 mL per year). The estimated rates of decline from the regression model did not differ significantly (49.1 mL vs 46.0 mL per year; difference 3.1 mL per year [95% CI -12.8 to 19.0]; $p=0.7$). Before the study, the minimum relevant difference was defined as 20 mL per year; this difference was outside the 95% CI. No effect of inhaled budesonide was seen on respiratory symptoms. 316 exacerbations occurred during the study period, 155 in the budesonide group and 161 in the placebo

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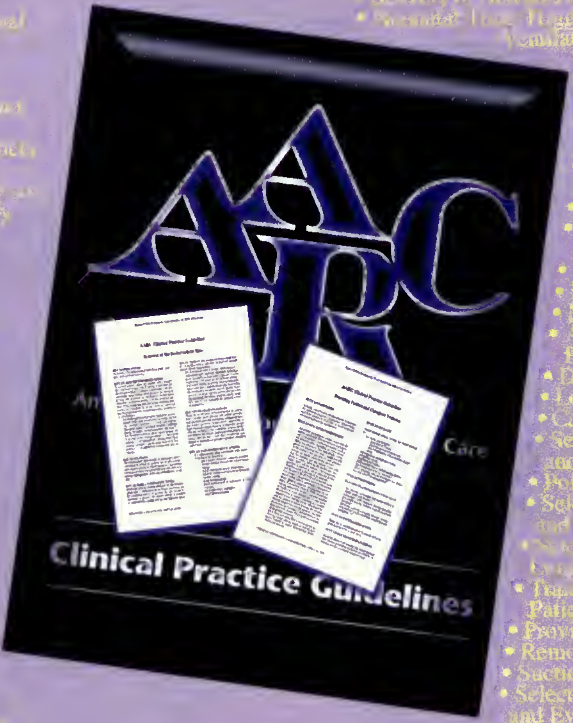
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group. Treatment was well tolerated. INTERPRETATION: Inhaled budesonide was of no clinical benefit in COPD patients recruited from the general population by screening. We question the role of long-term inhaled corticosteroids in the treatment of mild to moderate COPD.

Does the Murphy Eye Reduce the Reliability of Chest Auscultation in Detecting Endobronchial Intubation?—Sugiyama K, Yokoyama K, Satoh K, Nishihara M, Yoshitomi T. Anesth Analg 1999 Jun;88(6):1380-1383.

Bilateral breath sounds are routinely auscultated after endotracheal intubation to verify that the endotracheal tube (ETT) tip is properly positioned. We conducted the present study to ascertain whether the eye of the Murphy tube has an influence on the reliability of auscultation of breath sounds in detecting endobronchial intubation. Twenty patients undergoing scheduled oral and maxillofacial surgery participated in this study. After the induction of general anesthesia, either the Magill tube or the Murphy tube was inserted through the nose into the trachea. The fiberoptic bronchoscope was inserted through the ETT, and the distance from the nares to the carina of the trachea was measured. When breath sounds from the left side of the chest changed and disappeared while the ETT was being advanced, the distance from the nares to the ETT tip was measured. Unilateral auscultatory change was not observed until the ETT tip was advanced beyond the carina and inserted 1.5 ± 0.4 cm into the right mainstem bronchus when the Magill tube was used and 2.0 ± 0.4 cm when the Murphy tube was used ($p < 0.01$). Breath sounds disappeared when the ETT tip was further advanced up to 3.2 ± 0.3 cm from the carina. We demonstrated that the eye of the Murphy tube reduces the reliability of chest auscultation in detecting endobronchial intubation. IMPLICATIONS: The Murphy eye was designed to allow ventilation of the lung when the bevel of the endotracheal tube is occluded. We demonstrated that the eye of the Murphy tube reduces the reliability of chest auscultation in detecting endobronchial intubation.

Hemodynamic and Catecholamine Stress Responses to Insertion of the Combitube, Laryngeal Mask Airway or Tracheal Intubation—Oczenski W, Krenn H, Dahaba AA, Binder M, El-Schahawi-Kienzl I, Jellinek H, et al. Anesth Analg 1999 Jun;88(6):1389-1394.

In a prospective, randomized, and controlled trial, we compared the stress responses after insertion of the Combitube (CT; Kendall-Sheridan Catheter Corp., Argyle, NY), the laryngeal mask airway (LMA), or endotracheal intubation (ET). Seventy-five patients scheduled for routine urological or gynecological surgery were randomly allocated to one of three groups and were ventilated via either an ET, a LMA, or a CT. All three devices could be inserted easily and rapidly, providing adequate ventilation and oxygenation. Insertion of the CT was associated with a significant increase in mean maximal systolic arterial pressure (160 ± 32 mm Hg) and diastolic arterial pressure (91 ± 17 mm Hg) compared with ET (140 ± 24, 78 ± 11 mm Hg; $p < 0.05$, $p < 0.01$, respectively) or insertion of the LMA (115 ± 33,63 ± 22 mm Hg, both $p < 0.001$). The mean maximal epinephrine and norepinephrine plasma concentrations after insertion of the CT (37.3 ± 31.1 and 279 ± 139 pg/mL, respectively) were significantly higher than those after ET (35.8 ± 89.8 and 195 ± 58 pg/mL, respectively) or insertion of a LMA (17.3 ± 13.3 and 158 ± 67 pg/mL, respectively). This might be attributed to the pressure of the pharyngeal cuff of the CT on the anterior pharyngeal wall. We conclude that insertion of the CT causes a pronounced stress response and that precautions should be taken when used in patients at risk of hypertensive bleeding. IMPLICATIONS: In this study, we showed that the hemodynamic and catecholamine stress responses after insertion of the Combitube (Kendall-Sheridan Catheter Corp., Argyle, NY) were significantly higher compared with laryngeal mask airway or endotracheal intubation. We conclude that the increased stress response to insertion of a Combitube may represent a serious hazard to patients with cardiovascular disease.

Control of Methicillin-Resistant Staphylococcus Aureus in the Hospital Setting (review)—Herwaldt LA. Am J Med 1999 May 3;106(5A):11S-18S; discussion 48S-52S.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a common cause of nosocomial infections. Healthcare professionals in the United States should develop programs to prevent transmission of this organism within their institutions. Aggressive control efforts are justified for several reasons: (1) the incidence of nosocomial MRSA reflects the general effectiveness of infection control practice; (2) MRSA do not replace susceptible strains but instead increase the overall rate of nosocomial *S. aureus* infections; (3) MRSA infections cause substantial morbidity and mortality; (4) serious MRSA infections must be treated with vancomycin. Thus, in hospitals with high rates of MRSA, use of this antimicrobial agent increases, which in turn may increase the risk for selecting vancomycin-resistant enterococci. Hospitals have used numerous different approaches to control nosocomial spread of MRSA. Staff should choose a control method based on the prevalence of MRSA in their institution and in their referring facilities, the rate of nosocomial transmission of MRSA in their hospital, the risk factors present in their patient population, the reservoirs and modes of transmission specific to their

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hospital, and their resources. Any MRSA control plan must stress adherence to basic infection control measures, such as hand washing and contact isolation precautions. In addition, decolonization of patients and staff, control of antimicrobial use, surveillance cultures, and molecular typing may be helpful adjuncts.

Antibiotic Use in Patients Admitted with Acute Exacerbations of Chronic Obstructive Pulmonary Disease—Smith JA, Redman P, Woodhead MA. Eur Respir J 1999 Apr;13(4):835-838.

The objective of this report was to document the pattern of initial antibiotic prescribing in acute exacerbations of chronic obstructive pulmonary disease (COPD) in a hospital setting. All episodes of acute exacerbation of COPD, as diagnosed by the admitting doctor, in one hospital in the period January to May 1996, were identified. Case notes were reviewed retrospectively. Cases of radiographic pneumonia, bronchiectasis and incorrectly coded admissions were excluded. Symptoms, microbial cultures and initial antibiotic therapies were recorded. One hundred and fifty-nine patient episodes were identified; 40 were excluded yielding a sample of 119. Nineteen case notes were unavailable leaving a sample of 100 (84%) episodes. Eighty were treated with antibiotics on admission; amoxycillin was the most frequently prescribed, in 46 (58%) episodes. Of the antibiotic treated group, 42 (53%) patients were given dual therapy, most commonly a macrolide antibiotic with either amoxycillin or a cephalosporin. Intravenous treatment was used in 22 (28%) cases. The duration of intravenous treatment was >48 h in 12 (15%) cases. A total of 76 sputum samples were analysed from 55 patient episodes: 34 (45%) were culture positive. In 15 (27%) patient episodes, antibiotic therapy was changed or instituted on the basis of culture results. These data suggest that antibiotic treatment is not optimal, with overuse of antibiotics, especially intravenous and dual therapy.

The Cellular Composition of Induced Sputum in Chronic Obstructive Pulmonary Disease—Peleman RA, Rytila PH, Kips JC, Joos GF, Pauwels RA. Eur Respir J 1999 Apr;13(4):839-843.

Asthma and chronic obstructive pulmonary disease are characterized by airway inflammation, which can be assessed by bronchoscopic techniques as well as by the analysis of induced sputum. A method to induce sputum with inhaled hypertonic saline was adapted for use in 21 chronic obstructive pulmonary disease (COPD) patients (mean baseline forced expiratory volume in one second (FEV$_1$) 1.60 L, or 54% predicted) and in 16 healthy volunteers. The success rate and safety of the method, were investigated along with the reproducibility of cell counts and differences in cell counts between both groups. All subjects produced adequate samples and the procedure did not alter spirometric values. A marked sputum neutrophilia was noted in patients with COPD (74.9±4.7%), whereas mainly macrophages were seen in healthy volunteers (74.0±4.0%). Reliability of the cell counts was high, both within investigators ($r=0.99$ neutrophils, $r=0.99$ macrophages) and between investigators ($r=0.95$ neutrophils, $r=0.77$ macrophages). In patients with COPD, an inverse correlation was noted between percentage of neutrophils and FEV$_1$ ($r^2 0.48$, $p<0.05$). Immunostaining revealed a large proportion of activated macrophages in both groups. It was concluded that induction of sputum is a safe and reproducible method to study the composition of airway secretions in patients with chronic obstructive pulmonary disease.

Effect of Temperature on Lung Function and Symptoms in Chronic Obstructive Pulmonary Disease—Donaldson GC, Seemungal T, Jeffries DJ, Wedzicha JA. Eur Respir J 1999 Apr;13(4):844-849.

The present study investigated whether falls in environmental temperature increase morbidity from chronic obstructive pulmonary disease (COPD). Daily lung function and symptom data were collected over 12 months from 76 COPD patients living in East London and related to outdoor and bedroom temperature. Questionnaires were administered which asked primarily about the nature of night-time heating. A fall in outdoor or bedroom temperature was associated with increased frequency of exacerbation, and decline in lung function, irrespective of whether periods of exacerbation were excluded. Forced expiratory volume in one second (FEV$_1$) and forced vital capacity (FVC) fell markedly by a median of 45 mL (95% percentile range: -113-229 mL) and 74 mL (-454-991 mL), respectively, between the warmest and coolest week of the study. The questionnaire revealed that 10% had bedrooms <13 degrees C for 25% of the year, possibly because only 21% heated their bedrooms and 48% kept their windows open in November. Temperature-related reduction in lung function, and increase in exacerbations may contribute to the high level of cold-related morbidity from chronic obstructive pulmonary disease.

Respiratory Rehabilitation in Chronic Obstructive Pulmonary Disease: Predictors of Nonadherence—Young P, Dewse M, Fergusson W, Kolbe J. Eur Respir J 1999 Apr;13(4):855-859.

Rehabilitation is now an integral part of chronic obstructive pulmonary disease (COPD) management. The objective of the study was to determine predictors of nonadherence to a COPD rehabilitation programme. Patients attending a COPD clinic were invited to participate in a 4 week, hospital-based, outpatient, COPD rehabilitation programme conducted predominantly by respiratory physiotherapists. All potential participants undertook an interviewer administered questionnaire addressing social, economic, psychological and healthcare factors, and underwent baseline physiological measures. Subsequently they were classified as: 1) 'adherent' group who completed the total programme (n=55) or 2) 'nonadherent' group who refused or began but did not complete the programme (n=36). The nonadherent group compared to the adherent group were more likely to be divorced (22 versus 2%, $p<0.005$), live alone (39 versus 14%, $p<0.02$), and to live in rented accommodation (31 versus 6%, $p<0.005$). There were no differences between the two groups in terms of baseline physiological parameters (forced expiratory volume in one second, forced vital capacity, 6-min walk distance, oxygen saturation, perceived dyspnoea), quality of life domains (Chronic Respiratory Disease Questionnaire), or indices of COPD-related morbidity. The nonadherent group were more likely to be current smokers (28 versus 8%, $p<0.02$) and less likely to use inhaled corticosteroids (16 versus 42%, $p<0.005$). The nonadherent group was not significantly likely to be depressed, anxious, prone to hyperventilation or to have had previous emotional counselling and was more likely to be dissatisfied with disease-specific social support (51 versus 2%, $p<0.001$). In conclusion, a substantial proportion of eligible subjects who did not participate in a chronic obstructive pulmonary disease rehabilitation programme were not more physiologically impaired, but were more likely to be: socially isolated, lack chronic obstructive pulmonary disease-related social support, still be smoking and be less compliant with other healthcare activities. Identification of one or more of these factors reliably allows prediction for nonadherence to a rehabilitation programme.

Assessment of Bronchial Reactivity by Forced Oscillation Admittance Avoids the Upper Airway Artefact—Farre R, Rotger M, Marchal F, Peslin R, Navajas D. Eur Respir J 1999 Apr;13(4):761-766.

The forced oscillation technique (FOT) allows easy assessment of bronchial reactivity. The use of a standard FOT generator (SG) results in changes in respiratory system resistance (Δ Rrs,SG) which are affected by an artefact caused by the extrathoracic upper airway (EUA). The aim was to improve the FOT assessment of bronchial reactivity with the SG by computing the change in FOT admittance (Δ Ars,SG), which is theoretically unaffected by this artefact. Δ Rrs,SG and Δ Ars,SG after bronchial challenge in 17 children were compared with the values measured with a head generator (HG) FOT setup (Δ Rrs,HG and Δ Ars,HG, respectively), which were taken as a reference, since HG provides data virtually freed from the EUA artefact. At 10 Hz, the SG significantly underestimated the resistance change: Δ Rrs,SG$=1.77\pm0.62$ versus Δ Rrs,HG$=6.09\pm1.23$ hPa x L^{-1} x s. Δ Rrs,SG and Δ Rrs,HG did not show a significant correlation. By contrast, the amplitude of the change in admittance measured by SG was close to the one obtained with the reference HG: /Δ Ars,SG/$=29.5\pm4.6$ versus /Δ Ars,HG/$=32.7\pm3.9$ mL x hPa^{-1} x s^{-1}. /Δ Ars,SG/ and /Δ Ars,HG/ showed a significant correlation ($r=0.65$, $p>0.01$). Similar results were found up to 20 Hz. The extrathoracic upper airway artefact was minimized when computing the change in admittance with the standard generator. This forced oscillation technique index may improve the sensitivity in assessing bronchial reactivity with the standard generator setup, which is the most common and easiest to use method for routine lung function testing.

Changes in Airway Resistance Induced by Nasal or Oral Intermittent Positive Pressure Ventilation in Normal Individuals—Fontanari P, Burnet H, Zattara-Hartmann MC, Badier M, Jammes Y. Eur Respir J 1999 Apr;13(4):867-872.

Nasal intermittent positive-pressure ventilation (nIPPV) is used for the treatment of respiratory failure in patients with neuromuscular disease. The aim of the present study was to demonstrate that nIPPV may activate nose receptors, the consequence of which being reflex changes in lung resistance. The changes in interrupter resistances (Rint) in response to nIPPV were tested before and after local anaesthesia of the nasal mucosa in normal subjects. They were compared to the Rint changes induced by oral intermittent positive-pressure ventilation (oIPPV) in the same individuals. Rint was measured during 10-min periods of nIPPV or oIPPV at a constant rate (15 L x min^{-1}), but at two different stroke volumes (0.8 and 1.2 L). Inspired temperature and relative humidity were held constant. nIPPV with 1.2 L (17 mL x kg^{-1}) significantly increased the Rint value (+22%). This effect disappeared after nose anaesthesia or after inhalation of a cholinergic antagonist. oIPPV never changed Rint, even though the associated hypocapnia was present and more accentuated than during nIPPV. Adding CO_2 to the inspired gas during nIPPV and oIPPV trials suppressed the Rint changes. The present study suggests the existence of a nasopulmonary bronchoconstrictor reflex elicited through the stimulation of nasal mechanoreceptors, their activity being markedly influenced by the changes in expired CO_2.

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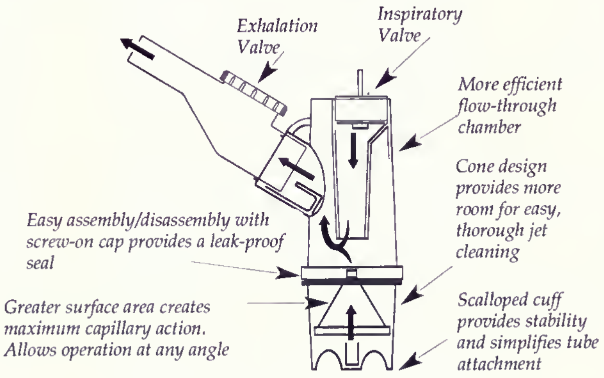
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Effects of Chemical Feedback on Respiratory Motor and Ventilatory Output During Different Modes of Assisted Mechanical Ventilation—Mitrouska J, Xirouchaki N, Patakas D, Siafakas N, Georgopoulos D. Eur Respir J 1999 Apr;13(4):873-882.

The purpose of the study was to examine the effects of chemical feedback on respiratory motor and ventilatory output in conscious subjects ventilated on various modes of assisted mechanical ventilation. Seven subjects were connected to a ventilator and randomly ventilated on assist-volume control (AVC), pressure support (PS) or proportional assist ventilation (PAV). On each mode, the assist level was set to the highest comfortable level. Airway and oesophageal (P_{oes}) pressures, tidal volume, respiratory frequency (fR) and end-tidal carbon dioxide tension (P_{ETCO_2}) were measured breath-by-breath. When the subjects were stable on each mode, the fraction of inspired carbon dioxide (F_{ICO_2}) was increased stepwise, and changes in minute ventilation ($\dot{V}_E$) and respiratory motor output, estimated by the pressure-time product of all the respiratory muscles per breath (PTPrm) and per minute (PTPminute), were observed. At zero F_{ICO_2}, PTPminute/P_{ETCO_2} did not differ between modes, while $\dot{V}_E$/ PTPminute was significantly lower with PAV than that with PS and AVC. As a result $\dot{V}_E/P_{ETCO_2}$ was significantly lower with PAV, preventing, unlike AVC and PS, a significant drop in P_{ETCO_2}. With PAV, independent of CO_2, $\dot{V}_E$/PTPminute remained constant, while it decreased significantly with increasing CO_2 stimulus with PS and AVC. At high P_{ETCO_2} respiratory effort was significantly lower with PAV than that with PS and AVC. In conclusion, the mode of mechanical ventilation modifies the effects of chemical feedback on respiratory motor and ventilatory output. At all carbon dioxide stimulus levels neuroventilatory coupling was better preserved with proportional assist ventilation than with pressure support and assist-volume control ventilation.

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Severe Respiratory Failure Requiring ICU Admission in Bone Marrow Transplant Recipients—Gruson D, Hilbert G, Portel L, Boiron JM, Bebear CM, Vargas F, et al. Eur Respir J 1999 Apr;13(4):883-887.

Two groups of bone marrow transplant (BMT) recipients with febrile noncardiogenic respiratory failure requiring intensive care unit (ICU) admission, in the early phase of bone marrow transplantation were compared: those who had proven infectious pneumonia and those in whom bronchoalveolar lavage (BAL) failed to establish a diagnosis. Thirty-eight consecutive neutropenic BMT recipients admitted to an ICU with febrile noncardiogenic respiratory failure were enrolled. All of them underwent a BAL with viral, fungal, bacterial, and histopathological examinations. Lung biopsies were performed in nonsurviving patients in order to compare with BAL results. Haematological, biological, respiratory failure and other organ failure parameters, infectious results, outcome, and lung biopsy results were evaluated. BAL allowed an infectious diagnosis to be established in 16 BMT recipients. No aetiology was proven in 22 patients. Without a significant difference in respiratory failure parameters on ICU admission, noninvasive continuous positive airway pressure ventilation, which was given to 11 patients in each group, was significantly more successful in patients with proven infectious pneumonia (6 of 11 versus 0 of 11 patients) and enabled endotracheal intubation to be avoided in significantly more patients with infectious disease (10 of 16 versus 22 of 22 patients). The evolution of patients without diagnosis was significantly different with more frequent renal failure, hepatic failure, and death (20 of 22 versus 9 of 16 patients). Post mortem biopsies confirmed the absence of micro-organisms, but endothelial damage and fibrosis was found in 14 of the 22 patients. In conclusion, in the early phase of bone marrow transplantation the recipients without proven aetiology of pneumonia have a worse outcome than grafted patients with proven infectiuous pneumonia.

Variability of Aerosol Delivery via Spacer Devices in Young Asthmatic Children in Daily Life—Janssens HM, Devadason SG, Hop WC, LeSouef PN, De Jongste JC, Tiddens HA. Eur Respir J 1999 Apr;13(4):787-791.

Pressurized metered dose inhalers (pMDI) are widely used together with spacers for the treatment of asthma in children. However, the variability of daily medication dose for pMDI/spacer combinations is not known. Electrostatic charge is a potential source of dose variability. Metal spacers have no static charge. This study assessed and compared within-subject variability of aerosol delivery of metal and plastic spacers. This was a randomized, crossover study in children with stable asthma aged 1-4 (group I, n=17) and 5-8 (group II, n=16) yrs. In both groups the amount of drug delivered to the mouth by a metal spacer (Nebuchamber) and one of two plastic (polycarbonate) spacers, i.e. Babyhaler in group I and Volumatic in group II was measured. The metal and plastic spacers were tested at home in a randomized order for 7 days each, using budesonide (200 microg b.i.d.). Aerosol was collected on a filter positioned between spacer and facemask or mouth. Budesonide on the filter was assessed by high performance liquid chromatography. The mean filter dose for each child (mean±SD) during the 7 days was

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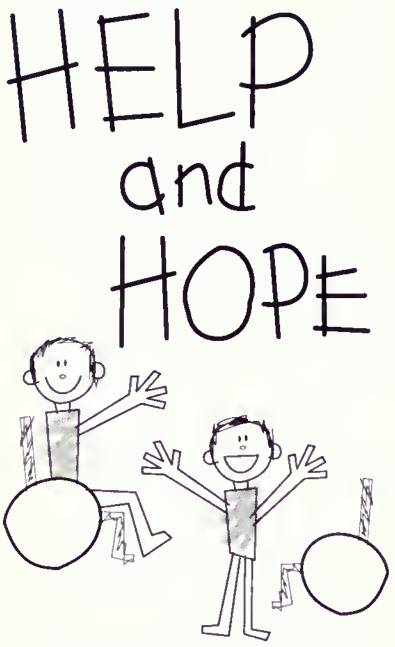
expressed as a percentage of the nominal dose. Within-subject variability was expressed as coefficient of variation (CV). Mean filter dose in group I was 41.7±10.1% for Nebuchamber and 26.0±4.0% for Babyhaler ($p<0.001$). Mean filter dose in group II was 50.2±9.2% for Nebuchamber and 19.4±7.2% for Volumatic ($p<0.001$). Mean CV in group I was 34% for Nebuchamber and 37% for Babyhaler ($p=0.44$). Mean CV in group II was 23% for Nebuchamber and 34% for Volumatic ($p=0.003$). There was substantial within-subject dose variability in aerosol delivery in children using a pMDI/spacer at home. This variability was lower for the metal than for the plastic spacer in children 5-8 yrs of age. The dose delivered to the mouth was about two-fold higher for the metal than the plastic spacer independent of age.

Multidisciplinary Approach to Management of Postintubatinn Tracheal Stenoses—Brichet A, Verkindre C, Dupont J, Carlier ML, Darras J, Wurtz A, et al. Eur Respir J 1999 Apr;13(4):888-893.

The optimal management of postintubation tracheal stenosis is not well defined. A therapeutic algorithm was designed by thoracic surgeons, ear, nose and throat (ENT) surgeons, anaesthetists and pulmonologists. Rigid bronchoscopy with neodymium-yttrium aluminium garnet (Nd-YAG) laser resection or stent implantation (removable stent) was proposed as first-line treatment, depending on the type of stenosis (web-like versus complex stenosis). In patients with web-like stenoses, sleeve resection was proposed when laser treatment (up to three sessions) failed. In patients with complex stenoses, operability was assessed 6 months after stent implantation. If the patient was judged operable, the stent was removed and the patient underwent surgery if the stenosis recurred. This algorithm was validated prospectively in a series of 32 consecutive patients. Three patients died from severe coexistent illness shortly after the first bronchoscopy. Of the 15 patients with web-like stenosis, laser resection was curative in 10 (66%). Among the 17 patients with complex stenoses, three remained symptom-free after stent removal. Bronchoscopy alone was thus curative in more than one-third of the patients. Six patients underwent surgery, two after failure of laser resection and four after failure of temporary stenting. Surgery was always performed with the patient in good operative condition. Palliative stenting was the definitive treatment in nine cases. Tracheostomy was the definitive solution in two cases. This approach, including an initial conservative treatment, depending on the type of the stenosis, appears to be applicable to almost all patients and allows secondary surgery to be performed with the patient in good condition.



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Outcome of Asthma: Longitudinal Changes in Lung Function—Ulrik CS. Eur Respir J 1999 Apr;13(4):904-918.

Current knowledge about factors determining outcome of asthma is limited, but observations over the last few decades suggest that active asthma has a negative impact on the longitudinal changes in lung function. This review aims to give an overview of the present knowledge concerning longitudinal changes in lung function, including clinical markers for distinctly poor outcome with regard to lung function, in children and adults suffering from asthma. The majority of patients with asthma have a good prognosis. However, some patients with asthma, especially those with more severe disease, are at risk of impaired growth of lung function during childhood, a lower maximally attained level of lung function and excessive decline in lung function in adulthood, which may lead to life-threatening lung function impairment. Clinical markers of poorly controlled airway inflammation appear to have a negative impact on the longitudinal changes in lung function, and disease progression to nonreversible airflow obstruction may be observed in a minority of patients with asthma. Early intervention with anti-inflammatory therapy may improve the short-term outcome of asthma, but long-term controlled studies are clearly needed in order to verify whether or not treatment, especially with inhaled corticosteroids, according to the current international guidelines alters the natural history of asthma, i.e. disease progression with regard to changes in lung function and possible development of nonreversible airflow obstruction.

Relation of Body Position at the Time of Discovery eith Suspected Aspiration Pneumonia in Poisoned Comatose Patients—Adnet F, Borron SW, Finot MA, Minadeo J, Baud FJ. Crit Care Med 1999 Apr;27(4):745-748.

OBJECTIVE: The left lateral decubitus position is generally accepted as the position of choice to protect against aspiration pneumonia in comatose poisoned patients. We studied the relationship between initial body position during coma and subsequent development of suspected aspiration pneumonia (SAP). DESIGN: Observational, descriptive study. SETTING: Toxicology intensive care unit in a university hospital. PATIENTS: Acutely poisoned comatose patients admitted to our intensive care unit. INTERVENTIONS: None. MEASUREMENTS AND MAIN RESULTS: Glasgow Coma Scale score (GCS) and body position were recorded in poisoned patients on discovery. Chest radiographs were examined for infiltrates

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suggesting SAP within 24 hrs of hospitalization. The prone positioned patients had a lower incidence of SAP than patients in the lateral decubitus and supine positions, despite similar GCS scores. Patients in the semi-recumbent position had an incidence of SAP similar to prone patients, but with higher GCS values. CONCLUSIONS: The prone position appears to be associated with a lower incidence of SAP than the lateral decubitus position in comatose poisoned patients.

Effects of Pressure Ramp Slope Values on the Work of Breathing During Pressure Support Ventilation in Restrictive Patients—Bonmarchand G, Chevron V, Menard JF, Girault C, Moritz-Berthelot F, Pasquis P, Leroy J. Crit Care Med 1999 Apr;27(4):715-722.

OBJECTIVE: To investigate, in restrictive patients, the influence of pressure ramp slope values on the efficacy of pressure support ventilation. DESIGN: Prospective study. SETTING: A university hospital medical intensive care unit. PATIENTS: Twelve intubated restrictive patients. INTERVENTIONS: Patients were randomly assigned to four sequences in which the values of the slope of the pressure ramp increase were modulated so that the plateau pressure was reached within a predetermined time: 0.1, 0.50, 1, or 1.50 secs. The more rapidly the pressure plateau was achieved, the higher was the initial flow rate. For convenience, these four different ventilatory settings were termed T 0.1, T 0.5, T 1, and T 1.5. MEASUREMENTS AND MAIN RESULTS: We measured the following parameters 10 mins after application of each pressure ramp slope: inspiratory work of breathing, breathing pattern, and intrinsic PEEP (PEEPi). Work of breathing was evaluated using Campbell's diagram, and expressed as a percentage of the values observed under spontaneous ventilation. A marked interindividual variation of the values for work of breathing was observed under spontaneous ventilation; the mean value for work of breathing was 1.97 ± 0.82 joule/L, with a range of 1.22 to 4.10 joule/L. Comparison between the means for each sequence and each variable measured was performed by two-way analysis of variance with internal comparisons between sequences by Duncan's test. Between the first (T 0.1) and the last (T 1.5) sequence, the reduction of values of the pressure ramp slope induced a progressive increase in the values for work of breathing, regardless of the mode of expression (in joule, joule/L, or joule/min). The values for work of breathing (joule/ L), expressed as a percentage of the values observed under spontaneous ventilation, increased from 44.2 ± 14.4% to 78.3 ± 17.8% ($p < 0.001$). In contrast, the reduction of the pressure ramp slope values and initial flow rate did not induce any significant change in tidal volume, respiratory frequency, and PEEPi. CONCLUSION: Among the four tested slope values, the steepest was that which induced the lowest possible work of breathing in restrictive patients ventilated by pressure support ventilation. In this type of patient, we therefore suggest that the programmed pressure value should be reached by using a steep pressure ramp slope.

Purine in Bronchoalveolar Lavage Fluid as a Marker of Ventilation-Induced Lung Injury—Verbrugge SJ, de Jong JW, Keijzer E, de Anda GV, Lachmann B. Crit Care Med 1999 Apr;27(4):779-783.

OBJECTIVE: To investigate in a rat model of ventilation-induced lung injury whether metabolic changes in the lung are reflected by an increased purine concentration (adenosine, inosine, hypoxanthine, xanthine, and urate; an index of adenosine-triphosphate breakdown) of the bronchoalveolar lavage fluid and whether purine can, thus, indirectly serve as a marker of ventilation-induced lung injury. DESIGN: Prospective, randomized, controlled trial. SETTING: Research laboratory. SUBJECTS: Forty-two male Sprague-Dawley rats. INTERVENTIONS: Five groups of Sprague-Dawley rats were subjected to 6 mins of mechanical ventilation. One group was ventilated at a peak inspiratory pressure of 7 cm H_2O and a positive end-expiratory pressure of 0 cm H_2O. A second group was ventilated at a peak inspiratory pressure of 45 cm H_2O and a positive end-expiratory pressure of 10 cm H_2O. Three groups of Sprague-Dawley rats were ventilated at a peak inspiratory pressure of 45 cm H_2O without positive end-expiratory pressure. Before mechanical ventilation, two of these groups received intratracheal administration of saline or exogenous surfactant at a dose of 100 mg/kg and one group received no intratracheal administration. A sixth group served as the nonventilated controls. MEASUREMENTS AND MAIN RESULTS: Bronchoalveolar lavage fluid was collected in which both purine concentration (microM; mean ± SD) and protein concentration (mg/mL; mean ± SD) were determined. Statistical differences were analyzed using the one-way analysis of variance (ANOVA) with a Student-Newman-Keul's post hoc test. Purine and protein concentrations were different between groups (ANOVA p value for purine and protein, <0.0001). Both purine and protein concentrations in bronchoalveolar lavage fluid were increased in Group 45/0 (3.2 ± 1.9 and 4.2 ± 1.6, respectively) compared with Group 7/0 (0.4 ± 0.1 [$p < 0.05$] and 0.4 ± 0.2 [$p < 0.001$]) and controls (0.2 ± 0.2 [$p < 0.01$] and 0.2 ± 0.1 [$p < 0.001$]) and in Group 45/Na (5.8 ± 2.5 and 4.2 ± 0.5) compared with Group 7/0 (purine and protein, $p < 0.001$) and the controls (purine and protein, $p < 0.001$). Positive end-expiratory pressure prevented an increase in purine and protein concentrations in bronchoalveolar lavage fluid (0.4 ± 0.3 and 0.4 ± 0.2, respectively) compared with Group 45/0 (purine, $p < 0.01$; protein, $p < 0.001$) and Group 45/Na (purine and protein, $p < 0.001$). Surfactant instillation preceding lung overinflation reduced purine and protein concentration in bronchoalveolar lavage fluid (2.1 ± 1.6 and 2.7 ± 1.0) compared with Group 45/Na (purine, $p < 0.001$; protein ($p < 0.01$). Surfactant instillation reduced protein concentration compared with Group 45/0 ($p < 0.01$). CONCLUSIONS: This study shows that metabolic changes in the lung as a result of ventilation-induced lung injury are reflected by an increased level of purine in the bronchoalveolar lavage fluid and that purine may, thus, serve as an early marker for ventilation-induced lung injury. Moreover, the study shows that both exogenous surfactant and positive end-expiratory pressure reduce protein infiltration and that positive end-expiratory pressure decreases the purine level in bronchoalveolar lavage fluid after lung overinflation.

A Comparison of Manual and Mechanical Ventilation During Pediatric Transport—Dockery WK, Futterman C, Keller SR, Sheridan MJ, Akl BF. Crit Care Med 1999 Apr; 27(4):802-806.

OBJECTIVE: To compare the amount of variability in ventilation during intrahospital transport of intubated pediatric patients ventilated either manually or with a transport ventilator. DESIGN: Prospective, randomized study. SETTING: Tertiary, multidisciplinary, pediatric intensive care unit. PATIENTS: Forty-nine pediatric postoperative heart patients who required transport while still intubated. INTERVENTIONS: Patients were randomized to receive either manual ventilation during transport or ventilation by a portable mechanical ventilator. Baseline ventilatory and hemodynamic parameters were recorded before and during transport. Before and after arterial blood gases were also obtained. All other aspects of care were identical. MEASUREMENTS AND MAIN RESULTS: There was a statistically significant greater amount of variation in ventilation during transport with manual technique as opposed to the mechanical ventilator. A Student's t-test on pre- to post-blood gas differences showed a significantly lower P_{etCO_2} ($p = 0.02$) in the manually ventilated patients when compared with the mechanically ventilated patients. Values for P_{CO_2} were higher, but only marginally significant ($p = 0.08$). Repeated measures analysis of variance using these same pre- and post blood gas values confirmed the significant decrease in P_{etCO_2} ($p = 0.05$). Minute to minute variation in P_{etCO_2} during transport was greater and the mean values significantly lower in the manually ventilated group ($p < 0.05$). Hemodynamic data were remarkably stable when examined both before and after transport and on a minute to minute basis during transport. CONCLUSIONS: Manual ventilation during intrahospital transport results in greater fluctuation of ventilatory parameters from an established baseline than does use of a transport ventilator. No clinically significant changes in status occurred during the brief period of transport studied.

Guidelines for Developing Admission and Discharge Policies for the Pediatric Intensive Care Unit. Pediatric Section Task Force on Admission and Discharge Criteria, Society of Critical Care Medicine in Conjunction with the American College of Critical Care Medicine and the Committee on Hospital Care of the American Academy of Pediatrics. Crit Care Med 1999 Apr;27(4):843-845.

These guidelines were developed to provide a reference for preparing policies on admission and discharge for pediatric intensive care units (PICUs). They represent a consensus opinion of physicians, nurses, and allied health care professionals. By using this document as a framework for developing multidisciplinary admission and discharge policies, utilization of pediatric intensive care units can be optimized and patients can receive the level of care appropriate for their condition.

Screening Older Patients for Obstructive Airways Disease in a Semi-Rural Practice—Dickinson JA, Meaker M, Searle M, Ratcliffe G. Thorax 1999 Jun;54(6):501-505.

BACKGROUND: Obstructive airways disease in older patients is reported to be not only common, but frequently overlooked and untreated by general practitioners. This study examines the value of screening elderly patients in a large semi-rural general practice for potentially treatable asthma and chronic obstructive pulmonary disease (COPD). METHODS: A random sample of 353 patients aged 60-75 years attended a nurse run screening clinic for pulmonary function testing, serial peak flow recording, and completion of a symptom questionnaire. Patients with a low forced expiratory volume in one second (below the fifth centile of their predicted value) or >15% mean diurnal variation in peak flow were referred to a doctor's clinic for further diagnostic assessment and/or to discuss possible treatment where appropriate. RESULTS: Fifty eight patients (16.4%) had obstructive airways disease, the prevalence of asthma being 6.5% and that of COPD 9.9%. Of these, 30 had no previous diagnosis of airways disease and

were not on treatment; eight of them had significant airways reversibility and 10 were current smokers. No newly diagnosed patients had severe disease as measured by pulmonary function or quality of life assessment, and six patients accepted treatment. CONCLUSION: Few older patients benefited from a screening programme for obstructive airways disease in a semi-rural general practice.

Nasal Pressure Recording in the Diagnosis of Sleep Apnoea Hypopnoea Syndrome—Series F, Marc I. Thorax 1999 Jun;54(6):506-510.

BACKGROUND: Nasal pressure tracing is now being used to measure breathing in ambulatory screening devices for sleep apnoea but it has not been compared with other methods of assessment. METHODS: Sleep induced breathing disorders were scored by three different methods of analysis (thermistry, inductive plethysmography, and nasal pressure tracing) in 193 consecutive patients referred to our sleep laboratory. With the conventional thermistry method an apnoea was defined as the absence of oronasal flow on the thermistor signal for ≥10 s and a hypopnoea as a 50% decrease in the sum signal of inductive plethysmography tracing for ≥10 s associated with an arousal and/or a 2% decrease in S_{aO_2}. Nasal pressure was measured via nasal prongs connected to a pressure transducer. Using the thermistor signal alone, a hypopnoea was defined as a 50% decrease in the signal for ≥10 s associated with an arousal and/or a 2% decrease in S_{aO_2}. A similar definition of apnoea and hypopnoea was used for nasal pressure, the fall in pressure being substituted for the thermistor reading. RESULTS: Impaired nasal ventilation prevented adequate measurements of nasal pressure in 9% of subjects. According to the conventional method of interpretation 107 subjects were identified as having the sleep apnoea hypopnoea syndrome (SAHS). The apnoea + hypopnoea index (AHI) was significantly lower using the thermistry method than with conventional analysis (mean difference -4.3/h, 95% CI -5.3 to -3.2, $p<10^{-4}$); 39% of conventional hypopnoeic events were scored as apnoeas using nasal pressure scoring. Apnoeic and hypopnoeic events could also be observed without any change in thermistor and sum Respitrace signals that resumed with the occurrence of arousals or awakenings. The AHI was significantly higher with nasal pressure scoring than with the conventional method (mean difference 4.5, 95% CI 3.4 to 5.6, $p<10^{-4}$). The mean difference in apnoea index between conventional and nasal pressure scoring was -7.5/h (95% CI -8.9 to -6.1). In the 78 patients who did not have SAHS according to the conventional method of analysis there was a significant positive relationship between the arousal index and AHI measured by nasal pressure tracing ($R = 0.51$, $p<10^{-4}$). Seventeen of the 78 patients had an AHI of >15/h by the nasal pressure method of analysis. CONCLUSIONS: Nasal pressure recording provides a simple and reliable measurement of nocturnal breathing abnormalities and may identify breathing abnormalities associated with arousals that are missed by other diagnostic methods.

Handwashing with Soap or Alcoholic Solutions? A Randomized Clinical Trial of Its Effectiveness—Zaragoza M, Salles M, Gomez J, Bayas JM, Trilla A. Am J Infect Control 1999 Jun;27(3):258-261.

BACKGROUND: The effectiveness of an alcoholic solution compared with the standard hygienic handwashing procedure during regular work in clinical wards and intensive care units of a large public university hospital in Barcelona was assessed. METHODS: A prospective, randomized clinical trial with crossover design, paired data, and blind evaluation was done. Eligible health care workers (HCWs) included permanent and temporary HCWs of wards and intensive care units. From each category, a random sample of persons was selected. HCWs were randomly assigned to regular handwashing (liquid soap and water) or handwashing with the alcoholic solution by using a crossover design. The number of colony-forming units on agar plates from hands printing in 3 different samples was counted. RESULTS: A total of 47 HCWs were included. The average reduction in the number of colony-forming units from samples before handwashing to samples after handwashing was 49.6% for soap and water and 88.2% for the alcoholic solution. When both methods were compared, the average number of colony-forming units recovered after the procedure showed a statistically significant difference in favor of the alcoholic solution ($p < 0.001$). The alcoholic solution was well tolerated by HCWs. Overall acceptance rate was classified as 'good' by 72% of HCWs after 2 weeks use. Of all HCWs included, 9.3% stated that the use of the alcoholic solution worsened minor pre-existing skin conditions. CONCLUSIONS: Although the regular use of hygienic soap and water handwashing procedures is the gold standard, the use of alcoholic solutions is effective and safe and deserves more attention, especially in situations in which the handwashing compliance rate is hampered by architectural problems (lack of sinks) or nursing work overload.

Treatment of Occult Pneumothoraces from Blunt Trauma—Brasel KJ, Stafford RE, Weigelt JA, Tenquist JE, Borgstrom DC. J Trauma 1999 Jun;46(6):987-990; discussion 990-991.

BACKGROUND: Occult pneumothoraces (OPTXs) are seen on abdominal computed tomographic (CT) scans but not on routine chest x-ray films. Optimal treatment for blunt trauma OPTXs has not been defined. We hypothesized that OPTXs could be safely observed without need for a chest tube (CT). METHODS: A prospective trial randomized blunt trauma patients with OPTXs to CT scan or observation. Patients were not excluded for positive pressure ventilation. Primary outcome measures were respiratory distress and pneumothoraces progression. RESULTS: Thirty-nine patients with 44 pneumothoraces were enrolled. Eighteen patients received a CT scan, and 21 patients were observed. Nine patients in each group received positive pressure ventilation. There was no difference in overall complication rate. No patient had respiratory distress related to the OPTX or required emergent CT scan. CONCLUSIONS: Observation of OPTX is not associated with an increased incidence of pneumothorax progression or respiratory distress. These pneumothoraces can be safely observed in patients with blunt trauma injury regardless of the need for positive pressure ventilation.

Can the Distance Fallen Predict Serious Injury After a Fall from a Height?—Goodacre S, Than M, Goyder EC, Joseph AP. J Trauma 1999 Jun;46(6):1055-1058.

BACKGROUND: After a fall, the distance fallen is sometimes used to predict the injury severity. We aimed to examine how distance fallen performs as a predictor of major injury. METHOD: A cohort of trauma victims attending our emergency department after having fallen from a height was identified retrospectively, and data were collected regarding the fall and injuries sustained. Performance of threshold heights, ranging from 2 meters (6.6 feet) to 10 meters (32.8 feet), as a diagnostic test for major injury was assessed. RESULTS: Height fallen performed poorly over the range of thresholds used. At low thresholds, sensitivity was inadequate to rule out major trauma, whereas the low prevalence meant that, despite impressive specificity at higher thresholds, positive predictive value was poor. At the optimal threshold of 5 meters (16.4 feet), the positive predictive value was 0.17 and sensitivity was 0.33. CONCLUSION: Height of fall is a poor predictor of major injury.

Snowboarding Injuries of the Chest: Comparison with Skiing Injuries—Machida T, Hanazaki K, Ishizaka K, Nakamura M, Kobayashi O, Shibata H, et al. J Trauma 1999 Jun;46(6):1062-1065.

BACKGROUND: Snowboarding injuries have become more common with the remarkable increase in the sport's popularity. However, although there are many reports of orthopedic injuries caused by snowboarding, there are few reports on injuries to the chest. In this study, we attempted to identify the characteristics of snowboarding injuries of the chest in comparison

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with alpine skiing injuries. METHODS: Between December of 1988 and April of 1997, 1,579 and 9,108 patients were treated for snowboarding and skiing injuries, respectively. All patients were initially examined by emergency physicians who used chest x-ray film. Patients with known or suspected chest injuries were further examined by using chest computed tomography and ultrasonography by thoracic and general surgeons. A total of 96 snowboarding patients and 247 skiing patients had chest injuries. RESULTS: The chest injuries among snowboarders accounted for 6.1% of all injuries compared with only 2.7% amongst skiers. Snowboarders with chest injuries were younger, more often beginners, and more frequently occurred during the afternoon than skiers. Several distinct patterns of injury were noted among these two groups. As the cause of injury, a riding mistake during jumping was significantly higher for snowboarders (50.0%) than for skiers (0%). The incidence of rib fracture during snowboarding (55.2%) was significantly higher than during skiing (41.3%). There were no mortalities in either group. CONCLUSION: A riding mistake during improper jumping may be the primary cause of chest snowboarding injuries. Furthermore, snowboarders are much more likely to injure the chest, particularly by rib fractures, than skiers.

Cough, Cough Receptors, and Asthma in Children—Chang AB. Pediatr Pulmonol 1999 Jul;28(1):59–70.

This review discusses current general concepts on cough and the relationship between cough, cough receptor sensitivity, and asthma in children. It presents models of the relationship between cough and bronchoconstriction, and proposes a new model outlining the relationship between cough receptor sensitivity, airway hyperresponsiveness, and the clinical issues of cough, wheeze, and dyspnea in children with and without asthma. Cough is very common in children, with a prevalence of 15–20%. Those with non-specific cough (dry cough in the absence of identifiable respiratory illness) are often treated with a variety of drugs, in particular, medications for asthma and gastroesophageal reflux. However, there is little evidence to use these medications for the sole symptom of cough in children. Clinical studies on cough need to be interpreted in light of inherent methodological problems in studying cough. These methodological problems include the nonrepeatable nature of questions on cough, the unreliability of subjective measurements of cough, the lack of objective measurements to quantify cough severity, and the period effect (spontaneous resolution of cough). Although cough can be troublesome, cough serves as an important function for maintaining normal health of the respiratory system. The importance of cough in maintaining respiratory health is reflected in the development of lung atelactasis/collapse from retained secretions and recurrent pneumonia in clinical situations where the cough reflex is ineffective. The cough reflex is complex and still poorly understood. In this article the simplified cough pathway is presented and involves cough receptors, mediators of sensory nerves and the afferent pathway, the vagus nerve, the cough centre, efferent pathway, and cough effectors.

Prevalence of Atopy, Asthma Symptoms and Diagnosis, and the Management of Asthma: Comparison of an Affluent and a Non-Affluent Country—Faniran AO, Peat JK, Woolcock AJ. Thorax 1999 Jul;54(7):606–610.

BACKGROUND: The prevalence of childhood asthma and of atopy varies widely between countries. However, few studies have compared the pattern of diagnosis and management of asthma, or the role of atopy in predisposing to asthma between a less affluent country and a more affluent country. The aim of this study was to compare the prevalence of symptoms, diagnosis, and management of asthma, and the prevalence of atopy as measured by skin prick tests in Nigeria and Australia using a standardised methodology. METHODS: Respiratory history was collected using a validated questionnaire administered to parents, and atopy was measured with skin prick tests in 654 Australian and 566 Nigerian children aged 8–11 years (70% consent rate in Australia, 60% in Nigeria). RESULTS: Wheeze and persistent cough were less prevalent in Nigeria (10.2% and 5.1%, respectively) than in Australia (21.9% and 9.6%, respectively), caused less morbidity, and were less likely to be labeled or treated as asthma than in Australia. There was no significant difference in the overall prevalence of atopy between the two countries (Australia 32. 5%, Nigeria 28.2%). Atopy was a strong risk for wheeze in both countries (odds ratio (OR) 3.4 (95% CI 2.3 to 5.1) in Australia, 1.8 (95% CI 1.0 to 3.3) in Nigeria), especially atopy to house dust mites (OR 3.1 (95% CI 2.1 to 4.7) in Australia, 2.4 (95% CI 1.3 to 4. 3) in Nigeria). CONCLUSION: Although there was a similar prevalence of atopy in both countries, Australian children had a higher prevalence of asthma symptoms. Further studies are needed to determine why atopic children in Australia are more at risk of developing asthma. Such studies will have important implications for the prevention of asthma.

Asthma Guidelines: An Assessment of Physician Understanding and Practice—Doerschug KC, Peterson MW, Dayton CS, Kline JN. Am J Respir Crit Care Med 1999 Jun;159(6): 1735–1741.

In 1997 the NHLBI updated guidelines for the diagnosis and management of asthma. We hypothesized that not all components of the updated guidelines are well understood by the physicians who care for asthmatics. To develop appropriate educational interventions that address areas of physician misunderstanding, it is important to identify these components. Based upon NHLBI guidelines, we developed a multiple-choice test of asthma knowledge that was distributed to physicians at the University of Iowa; 108 physicians completed the test, including 20 asthma specialists, 11 asthma specialty fellows, 11 General Medicine faculty, five Family Medicine faculty, 51 Internal Medicine residents, and five Family Medicine residents. The mean correct total score for all physicians was 60± 2% (mean± SEM). Asthma specialists scored higher in total score and in pharmacology and prevention. However, no group performed well on estimating disease severity. We further identified deficits in the use of spirometry and anti-inflammatory agents in caring for asthmatic patients. Thus, deficits exist in physician understanding and implementation of the NHLBI guidelines for the diagnosis and management of asthma. By identifying specific areas of misunderstanding, we can design better educational interventions. Clearly, educational programs should emphasize new models for estimating chronic disease severity.

Exhaled Nitric Oxide As a Noninvasive Assessment of Chronic Cough—Chatkin JM, Ansarin K, Silkoff PE, McClean P, Gutierrez C, Zamel N, Chapman KR. Am J Respir Crit Care Med 1999 Jun;159(6):1810–1813.

Exhaled nitric oxide (ENO) has been suggested as a marker of airway inflammation. This study aimed to evaluate the role of ENO in the investigation of chronic cough. We measured ENO in 38 adult patients reporting chronic cough, in 23 healthy control subjects, and in 44 asthmatics. In addition to the regular investigation, ENO was measured by a chemiluminescent analyzer using the restricted breath technique. In the chronic cough group, 30 were considered as nonasthmatic, whereas asthma was diagnosed in eight by a positive methacholine challenge. ENO values were significantly higher in patients with chronic cough attributable to asthma as compared with those with chronic cough not attributable to asthma and to healthy volunteers (75.0 ppb; 16.7 ppb; and 28.3 ppb, respectively). The sensitivity and specificity of ENO for detecting asthma, using 30 ppb as the ENO cutoff point, were 75 and 87%, respectively. The positive and negative predictive values were 60 and 93%, and the positive and negative likelihood ratios were 5.8 and 0.3, respectively. We conclude that ENO may have a role in the evaluation of chronic cough. In this group of patients, low ENO suggested little likelihood of asthma. The patients with chronic cough not attributable to asthma showed a low ENO value as compared with healthy volunteers and asthmatics.

Mechanical Ventilator Malfunctions: A Descriptive and Comparative Study of 6 Common Ventilator Brands

Paul B Blanch RRT

BACKGROUND: Estimates suggest that there are as many as 50,000 mechanical ventilators in use in the United States alone. Yet, the medical literature is nearly devoid of information describing or discussing the issue of ventilator malfunctions. The purpose of this study was to investigate how and what types of mechanical ventilator malfunctions occur, whether there are significant differences in the malfunction rates of 6 common ventilator brands, and whether there are differences in ventilator purchase prices and long-term maintenance costs. MATERIALS AND METHODS: A retrospective review was done using hospital repair, maintenance, and billing records between July 1, 1991, and January 3, 1999. A total of 75 individual ventilators of 6 different brands were followed: 13 Bear Medical Cub ventilators (CUB), 11 Mallinckrodt Nellcor Puritan Bennett Infant Star ventilators (STAR), 8 Bird VIP ventilators (VIP), 11 Bird 6400ST ventilators (6400ST), 16 Bird 8400STi ventilators (8400 STi), and 16 Mallinckrodt Nellcor Puritan Bennett 7200ae ventilators (7200ae). The dependent variable was the operating time before malfunction, which was determined by the difference between hours logged on each ventilator's hour meter at the time of malfunction and that recorded at the outset of the study. Thereafter (when applicable), the time before malfunction was the difference in hours at successive malfunctions. Malfunctions were of 2 types: mechanical failures and operator errors. Price and maintenance information was obtained by personal communication. RESULTS: In 2,201,771 hours of ventilator operation, only 282 malfunctions were reported; of these, 176 were classified as mechanical failures, 106 as operator errors. There were no documented instances of long-term patient harm secondary to any type of ventilator malfunction. There were significant differences between some of the ventilator brands in the frequency of mechanical failures, operator errors, and the number of overall malfunctions experienced. There were also small differences in long-term maintenance costs, while purchase prices showed a considerably larger range. Curiously, modern ventilators may not suffer an increasing rate of malfunction as they age. Finally, if these 75 ventilators are representative of ventilators in general, modern ventilators may be as prone to human errors as were their predecessors. CONCLUSIONS: The data suggest that modern mechanical ventilators are rugged and safe, but not necessarily easier to use. Comparing differences in malfunction rates, maintenance costs, and purchase price offers hospitals a powerful tool for reducing the costs associated with mechanical ventilation. Furthermore, if the trend toward fewer malfunctions as a ventilator ages is validated, hospitals might wish to consider maintaining ventilators longer before replacing them. [Respir Care 1999;44(10):1183–1192] *Key words: mechanical ventilator malfunction, mechanical failure, maintenance cost, repair cost, operator error, survival analysis.*

Background

Several centuries ago, both Vesalius (1555) and Hooke (1667) demonstrated principles fundamental to the concept of mechanical ventilation.[1] Unfortunately, these pioneering efforts went virtually unrecognized, and mechanical ventilators did not gain widespread acceptance for nearly 200 years. Physicians in the United States were

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particularly recalcitrant; many still bitterly disputed the value of mechanical ventilation as late as the 1950s.[2] Eventually, it took a catastrophe (the polio epidemic of the mid-1950s) to irrefutably prove the value of mechanical ventilation. Since then, the growth in ventilator utilization has been nothing short of astonishing. Recent estimates suggest that today one third to one half of all intensive care unit (ICU) patients receive ventilatory support at some point during their hospital stay.[3] In the United States alone, 50,000 or more mechanical ventilators are currently in use, and, as many as 1,500,000 patients receive some form of ventilatory support outside of operating rooms and recovery rooms each year.[4,5]

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Considering the number of patients receiving ventilatory support, and the mechanical complexity of the ventilators now in use, a large number of ventilator malfunctions seem inevitable. Yet, the medical literature is nearly devoid of information describing or discussing the subject. Possibly, clinicians fear embarrassment or litigation[6] following publication of a report of complications secondary to a ventilator malfunction. Or clinicians might believe that because ventilators are so mechanically dissimilar, a problem associated with one brand would not be relevant to another.[6] Regardless of the cause, failure to report a ventilator malfunction delays expeditious solutions and increases the risk of recurrence of the same malfunction elsewhere. One example would be that, prior to the early 1970s, the temperature of gases inspired during mechanical ventilation often went unmonitored, until a report detailed a case of hemorrhagic, bronchospastic tracheobronchitis secondary to an overheated ventilator "hot pot."[7] More recently, safer pressure-relief valve designs and increased surveillance have followed publication of a fatal incident of neonatal pulmonary barotrauma involving such a valve.[8]

Along with a dearth of data describing ventilator malfunctions, virtually no independent scientific data exist comparing mechanical failure rates or the expected reliability of common ventilator brands. This fact is even more surprising because a single ventilator repair can cost $1,000 or more,[9,10] and most hospital administrators are currently preoccupied with cost-containment.

This study describes the number and types of malfunctions experienced by 6 common brands of mechanical ventilator used at 2 different institutions over a period of up to 90 months. The main objectives were to describe and characterize how and what types of mechanical ventilator malfunctions occur, whether there are differences in the rates of malfunction experienced by different brands of ventilators, and to compare how the long-term cost of owning one of the 6 different ventilator brands compares to the original purchase price.

Materials and Methods

The study consisted of a retrospective review and analysis of hospital billing records, and repair and maintenance records for 6 brands of mechanical ventilators at 2 institutions. A total of 75 ventilators were studied, including 13 Bear Cub Infant ventilators (CUB), 11 Mallinckrodt Nellcor Puritan Bennett Infant Star ventilators (STAR), 8 Bird VIP ventilators (VIP), 11 Bird 6400ST ventilators (6400ST), 16 Bird 8400STi (8400STi) ventilators, and 16 Mallinckrodt Nellcor Puritan Bennett 7200ae ventilators (7200ae).* Each ventilator was used for some portion of or throughout the period beginning July 1, 1991, and ending January 3, 1999. Ventilators of the studied brands, purchased during the course of the study, were enrolled in the study on the date they were placed into use. Once enrolled, each ventilator was either ready for use, or in use throughout the remainder of the study (except for time out for troubleshooting, repairs, or calibration). Each ventilator's age was determined by considering the month and year the ventilator was first available for use as its "birthday."

Institutional repair and maintenance records were obtained for each of the studied ventilators and used to determine the date each ventilator was first placed into service, the date each reported malfunction was noted, the total operating hours logged on the hour meter of each instrument when placed into use, and the hours logged on the day each malfunction was reported. These records also documented the nature and extent of patient injury (if any), and any resulting remedial actions.

Because during the course of the study most ventilators experienced several documented problems, the dependent variable of interest (malfunction) was recorded as a function of the number of hours a ventilator operated without incident between documented malfunctions.

While reviewing the repair and maintenance records, it became apparent that virtually all ventilator malfunctions involved either a mechanical failure or breakdown (including calibration errors) or some sort of operator (human) error. To determine whether a particular ventilator brand was more prone to either of these types of problems, each reported malfunction was categorized. A malfunction was considered a mechanical failure (failure) when the reported problem rendered the ventilator inoperable or unsafe to use until repaired or recalibrated; a malfunction was considered an operator error when, after thorough testing, the ventilator required no repairs or recalibration. For each studied ventilator, the uneventful operating time (in hours) between (or before) each malfunction was determined from the difference in total operating hours at successive reported malfunctions (or from the hours logged at the start of the study). Operating time was first determined between each successive malfunction of any type, and then between successive malfunctions of the same type (ie, between successive failures and/or successive operator errors).

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*Suppliers of commercial products are identified in the Product Sources section at the end of the text.

Manufacturers provided the retail cost of a fully equipped version of each studied brand of ventilator (except the CUB); they also provided the recommended preventive maintenance costs (all in 1999 dollars). The CUB is an exception because it is no longer commercially available; its reported retail cost reflects that in effect when it was removed from the market in 1996. Many CUBs remain in use today, so the preventive maintenance figures reflect those currently available.

Hospital billing records were used to determine the number of patients charged for a day of mechanical ventilation each month. This figure provides a reasonable estimate of ventilator use. It is an estimate because there were a few ventilators used that were not included in the study, and a patient is charged for an entire day of mechanical ventilation regardless of how many hours of that day they require use of the ventilator. Statistically speaking, the records revealed that for each "day" of mechanical ventilation billed, a ventilator operated, on average, between 21 and 22 hours. By combining monthly billing data with monthly malfunctions (failures and operator errors) and ventilator average age data, it was possible to visualize trends in ventilator utilization, average age of the ventilator fleet, rate of occurrence of malfunctions with respect to time, and the interrelationship between these factors over the entire course of the study period.

Statistical Analysis

In this study, the 3 outcome variables all involved the time (in hours) until a terminal event (a malfunction, failure, or operator error). Often, such variables are referred to as survival times because they give the time an individual survived before the terminal event. Survival data (see Appendix 1) present an important analytical problem—how to deal with incomplete or censored observations. Censored observations arise because some individuals may drop out before the study ends or survive until the study ends, so their survival time is indeterminate. Ordinary statistical techniques do not allow for censored observations, but omitting these data could seriously bias a study. For instance, imagine omitting only the study patients that actually survived cancer during trials of a new anti-cancer drug. To address this problem, a separate branch of statistics, known as survival analysis, evolved.

Data for the relative rates of malfunction, failure, and operator error were determined as means with standard deviations; the medians are also provided whenever possible. In some cases, data are presented as 12-month moving averages. Best-fit trend lines were determined using the technique of least squares. The 6 ventilator brands were compared using the survival analysis for multiple groups test; α was set at 0.05 for statistical significance, and post-hoc multiple comparisons were analyzed using the Cox-Mantel test.

For robustness, the multiple groups survival test depends on two important assumptions: (1) a fairly large sample size (at least 25–30 observations), and (2) that each observation is independent.[11] Because the 2 hospitals own a limited number of each studied ventilator brand, and malfunctions occur rather infrequently, gathering sufficient data in a reasonable interval presented an obstacle. However, the number of observations could be increased and data collection expedited if successive malfunctions (occurring with each studied ventilator) were considered as additional observations. This strategy, while practical, must not violate the independence assumption. For repeated operator errors, independence is assured; that is, one clinician's failure to properly use or understand a ventilator is unlikely to influence whether another clinician makes an operator error. Repeated failures are different; as a component within a ventilator fails, it could damage or weaken nearby components, reducing subsequent survival times. Despite this possibility, this premise was rejected and successive ventilator failures were considered independent observations, for two reasons. First, no credible scientific evidence has been published supporting or repudiating the premise; clinicians and hospital administrators assume a repaired ventilator is as safe and reliable as a new, never-before-repaired one. If it were otherwise, ventilators might be disposable items, legally speaking. Second, ventilator manufacturers mandate that field service engineers replace the entire failed subsystem—not just the failed component.

All descriptive statistics and hypothesis testing were performed using Statistica for Windows, release 5.1.

Results

During the 90-month study period, the 75 mechanical ventilators operated for a combined total of 2,201,771 hours (Table 1). During this time, clinicians reported a total of 282 malfunctions (not including censored observations). Table 1 shows a breakdown of ventilator utilization during the study and the types of malfunctions encountered, by ventilator type. None of the reported malfunctions resulted in documented patient injury. One hundred seventy-six (62.4%) of the malfunctions eventually required repair work

Table 1. Ventilator Utilization and Malfunctions by Ventilator Brand*

	CUB (*n* = 13)	STAR (*n* = 11)	VIP (*n* = 8)	6400ST (*n* = 11)	8400STi (*n* = 16)	7200ae (*n* = 16)	Totals (*n* = 75)
Malfunctions	36 (12)	45 (10)	34 (8)	66 (8)	26 (16)	75 (16)	282
Repairs	14 (12)	39 (10)	17 (8)	42 (8)	19 (16)	45 (16)	176
Operator errors	22 (13)	6 (11)	17 (8)	24 (11)	7 (16)	30 (16)	106
Use during study (h)	344,683	339,465	174,157	295,813	391,993	655,660	2,201,771
Use/year/ventilator (h)	3,632	4,784	3,915	3,426	4,698	6,535	4,647

*Number of censored observations are in parentheses. CUB = Bear Cub Infant ventilator; STAR = Mallinckrodt Nellcor Puritan Bennett Infant Star ventilator; VIP = Bird VIP ventilator; 6400ST = Bird 6400ST ventilator; 8400STi = Bird 8400STi ventilator; 7200ae = Mallinckrodt Nellcor Puritan Bennett 7200ae ventilator.

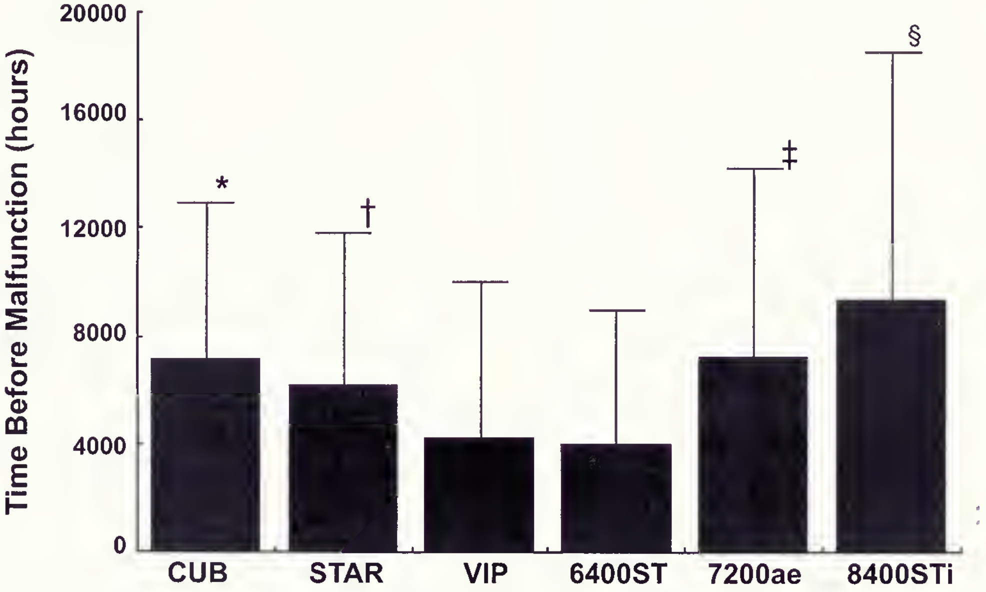

Fig. 1. Hours of ventilator operation before experiencing some sort of malfunction (time before malfunction) for each of the 6 ventilator brands studied. Data are mean ± SD. CUB = Bear Cub Infant ventilator. STAR = Mallinckrodt Nellcor Puritan Bennett Infant Star ventilator. VIP = Bird VIP ventilator. 6400ST = Bird 6400ST ventilator. 7200ae = Mallinckrodt Nellcor Puritan Bennett 7200ae ventilator. 8400STi = Bird 8400STi ventilator. * $p < 0.05$ compared to VIP, and 6400ST. † $p < 0.05$ compared to the 6400ST. ‡ $p < 0.05$ compared to VIP, and 6400ST. § $p < 0.05$ compared to STAR, VIP, 6400ST, and 7200ae.

(or calibration) and were classified as mechanical failures. The remaining 106 (37.6%) malfunctions were classified, by default, as operator errors.

At the end of the study period, the 75 ventilators ranged in age from 1.67 to 15.75 years (mean 8.57 years). Ventilators in this study averaged a malfunction once every 6,265 (3,689 median) hours of ventilator use, mechanical failures averaged once every 8,950 (5,842 median) hours, and operator errors averaged once every 12,158 (7,788 median) hours.

When comparing the relative frequency of malfunctions, mechanical failures, and operator errors, several statistically significant differences were noted within each category. The CUB for instance, operated significantly more hours before experiencing some sort of malfunction, compared to the VIP and 6400ST; the STAR operated successfully for longer than the 6400ST; the 7200ae operated longer than the VIP or the 6400ST; and the 8400STi operated longer than the STAR, VIP, 6400ST, or 7200ae (Fig. 1). The CUB was also significantly less likely to fail (or was more reliable) than either the STAR, VIP, or 6400ST. The 7200ae was more reliable than the STAR or the 6400ST. The 8400STi was more reliable than the STAR, the VIP, or the 6400ST (Fig. 2). The STAR was less likely to experience an operator error than the CUB, the VIP, the 6400ST, or the 7200ae. The 7200ae experienced fewer operator errors than the VIP. The 8400STi experienced fewer operator errors than the CUB, the VIP, the 6400ST, or the 7200ae (Fig. 3).

Purchase prices ranged from a low of $9,290 to a high of $28,865 (Table 2). Except for the CUB, which cost $5,600 for each 10,000 hours of use, preventive mainte-

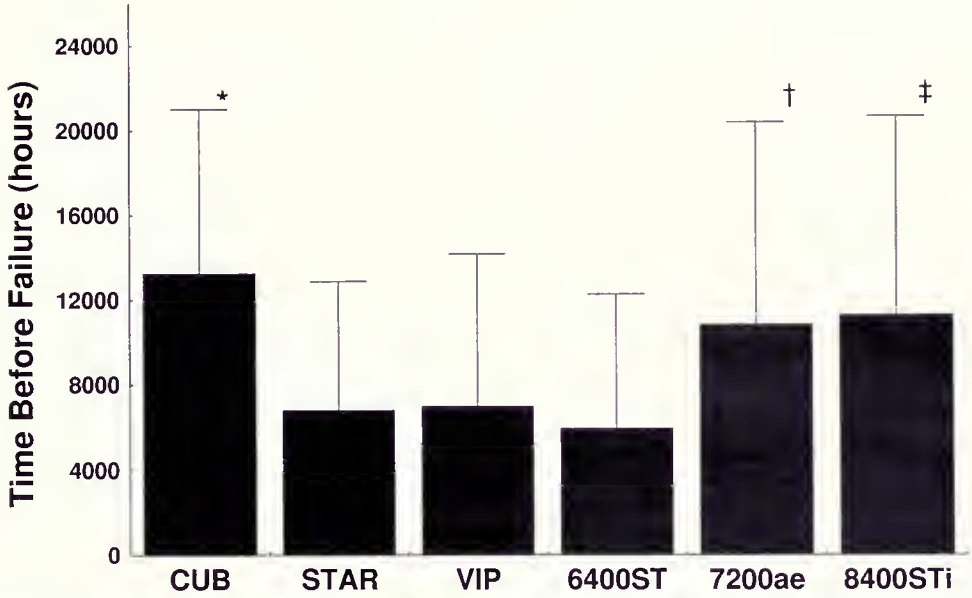

Fig. 2. Hours of ventilator operation before experiencing an unexpected mechanical failure (time before failure) for each of the 6 ventilator brands studied. Data are mean ± SD. CUB = Bear Cub Infant ventilator. STAR = Mallinckrodt Nellcor Puritan Bennett Infant Star ventilator. VIP = Bird VIP ventilator. 6400ST = Bird 6400ST ventilator. 7200ae = Mallinckrodt Nellcor Puritan Bennett 7200ae ventilator. 8400STi = Bird 8400STi ventilator. * $p < 0.05$ compared to the STAR, VIP, and 6400ST. † $p < 0.05$ compared to STAR, and 6400ST. ‡ $p < 0.05$ compared to STAR, VIP, and 6400ST.

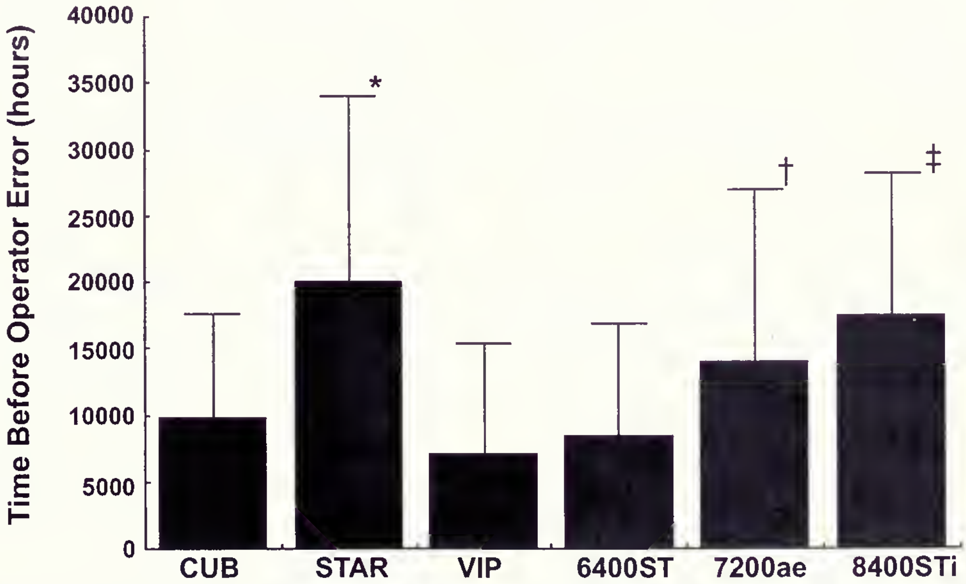

Fig. 3. Hours of ventilator operation before experiencing an unexpected operator error (time before operator error) for each of the 6 ventilator brands studied. Data are mean ± SD. CUB = Bear Cub Infant ventilator. STAR = Mallinckrodt Nellcor Puritan Bennett Infant Star ventilator. VIP = Bird VIP ventilator. 6400ST = Bird 6400ST ventilator. 7200ae = Mallinckrodt Nellcor Puritan Bennett 7200ae ventilator. 8400STi = Bird 8400STi ventilator. * $p < 0.05$ compared to CUB, VIP, 6400ST, and 7200ae. † $p < 0.05$ when compared to VIP. ‡ $p < 0.05$ compared to CUB, VIP, 6400ST, and 7200ae.

nance costs exhibited less range, between $1,865 and $3,063 for each 10,000 hours of use (see Table 2).

Time series data clearly show that even as the average age of the 75 ventilators increased from 3.71 to 8.57 years, the number of mechanical failures and operator errors experienced each month remained nearly constant (Fig. 4), despite increased utilization of the 75 ventilators. The average number of patient days of mechanical ventilation billed by the hospitals increased from 1,067 to 1,367 days per month (see Fig. 4).

Table 2. Ventilator Purchase Price and Long-Term Maintenance Costs by Ventilator Type

Ventilator brand	Purchase price (in 1999 $)	Maintenance cost per 10,000 h ($)	Maintenance cost per 50,000 h ($)	Total cost at 50,000 h ($)
CUB*	9,250	5,600	28,000	37,250
STAR	11,985	2,925	14,625	26,610
VIP	16,380	3,063	15,315	30,695
6400ST	9,290	2,800	14,000	23,290
8400STi	16,830	3,000	15,000	31,830
7200ae	28,865	1,865	9,325	38,190

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*No longer commercially available. Price is in 1996 dollars. CUB = Bear Cub Infant ventilator; STAR = Mallinckrodt Nellcor Puritan Bennett Infant Star ventilator; VIP = Bird VIP ventilator; 6400ST = Bird 6400ST ventilator; 8400STi = Bird 8400STi ventilator; 7200ae = Mallinckrodt Nellcor Puritan Bennett 7200ae ventilator.

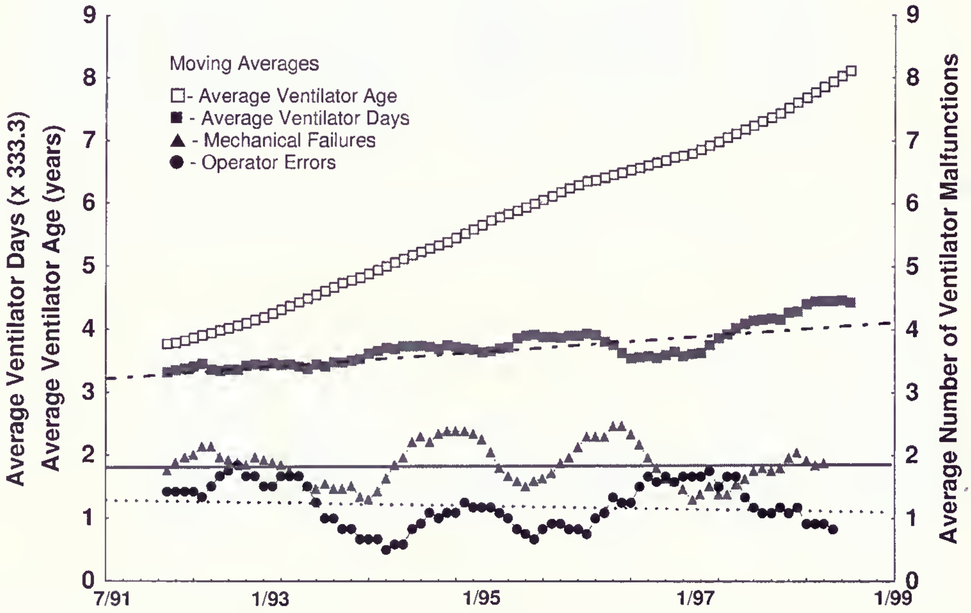

Fig. 4. Time series plot depicting variations in ventilator age (open squares), number of ventilator days billed by the hospital (squares), number of mechanical failures experienced each month (triangles), and number of operator errors experienced each month (circles) for the entire 90-month duration of the study. Superimposed on the time series data are best-fit trend lines, fitted using the least squares technique. Trends in number of ventilator days billed by the hospital each month (dashed line), number of mechanical failures each month (solid line), and number of operator errors experienced each month (dotted line) are shown. Data are centered, 12-month moving averages.

Discussion

Primary findings of this study include: (1) modern mechanical ventilators, when used and monitored carefully, appear to be extremely safe. In over 2,000,000 hours of ventilator use no documented instances of long-term patient harm followed any of the 282 reported malfunctions. (2) There are significant differences in the frequency of mechanical failures, operator errors, and total malfunctions among the 6 ventilator brands studied. (3) There are differences in the long-term maintenance costs associated with modern ventilators, and large differences in purchase price. (4) Modern mechanical ventilators do not seem to experience an increased incidence in any type of malfunction as they age, despite an increased utilization. In fact, these data suggest they may become more reliable with increasing age. (5) If these 75 ventilators are representative of ventilators in general, modern mechanical ventilators may be as prone to human errors as were their predecessors.

To my knowledge, data describing ventilator use and malfunctions, as presented in the Results and Table 1, are unique. Thus, these findings cannot yet be compared to others. The 2,201,771 hours of ventilator operation without documented long-term patient injury is noteworthy, but without comparable data on earlier vintage ventilators we cannot validate manufacturer claims that modern mechanical ventilators are safer.

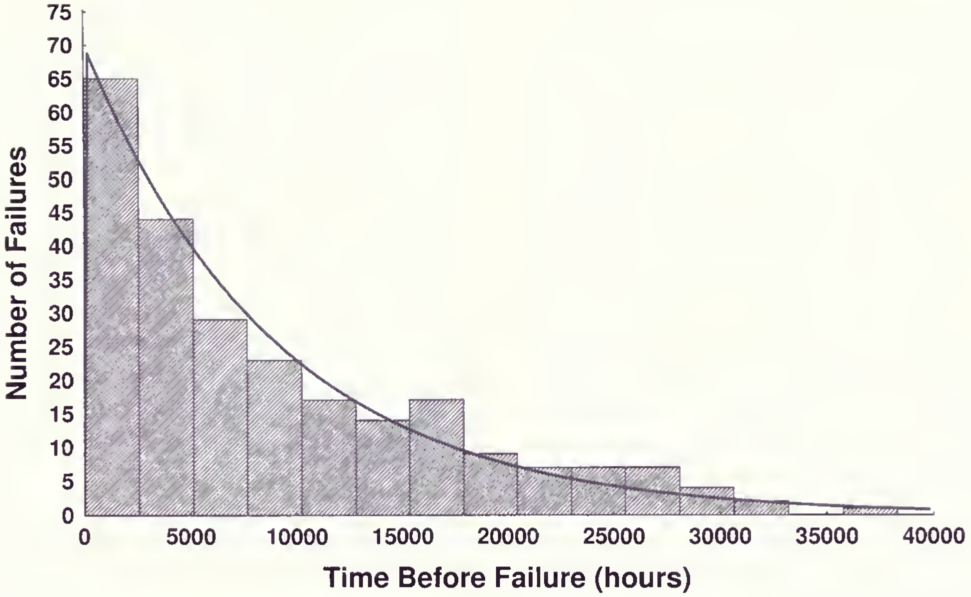

Fig. 5. Histogram plotting a series of 15 time intervals before mechanical failure against the number of ventilators experiencing mechanical failure within each time interval during the study. As expected for failure or survival times, data show a decidedly exponential or Weibull dispersion (as compared to Gaussian or normal dispersion). A representative exponential curve, of the form $y = ae^{-bx}$ is shown, where a and b are constant parameters of the distribution.

As noted, significant differences were found in the frequency of total malfunctions, mechanical failures, and operator errors experienced by some of the 6 ventilator brands. Such data could prove useful to someone considering which ventilator brand to purchase. For instance, the CUB was significantly less likely to experience a mechanical failure than the other infant ventilators (STAR, VIP). Or, if trying to decide between a 7200ae and 8400STi, it might be useful to note that while these 2 ventilators are *not* different in terms of mechanical failures, the 8400STi is significantly less likely to experience downtime as a result of operator errors.

The 75 ventilators included in this study represent, by definition, a convenience sample. Obtaining a truly independent and random sample could prove problematic, even with a multi-institutional study. Hospitals often utilize completely individualistic mixes of different types of ventilators, do not keep their own records, and buy ventilators in large quantities to save money, all of which make obtaining an independent and random sample difficult. Furthermore, a variety of factors affect the operating environment of a ventilator (including the frequency of electrical interruptions, brownouts, or water or other contamination in the compressed air) and would likely vary from one hospital to another. It would be unfair to compare a brand operated in a hostile environment to another brand operated under nearly optimal conditions. For these and other reasons (mentioned later), the reader is cautioned against placing too much importance on the exact times before malfunction, failure, or operator error. Nevertheless, although the exact hours before a malfunction might represent a questionable value, the *trends* observed are likely more reproducible because, though the operating environment and other factors vary from one institution to another, these factors remain consistent for each ventilator and brand of ventilator operating at each hospital. Therefore, regardless of the absolute number of hours measured before malfunction, if the CUB was more reliable than the STAR in one hospital, that trend is likely to be repeated elsewhere, regardless of the operating environment.

The astute observer may have noticed that some of the standard deviations (SD) are actually *larger* than the associated mean values (see Figs. 1–3). If these data were normally distributed, this situation would indicate extreme variance and very poor or possibly useless samples. However, failure or survival data such as this generally assumes exponential or Weibull dispersion (Fig. 5).[12] Such dispersion patterns always produce large SDs, and in some cases the SD exceeds the magnitude of the mean. Rather than attempt to explain such wide variances, some statisticians opt to report the median of such data sets, thereby avoiding the use of SDs altogether. Recognizing that most readers are more familiar with the concept of the mean and SD, and that the absolute values are of questionable importance, I have reported comparative values using the more traditional mean and SD. Whenever possible, the median value is also included parenthetically.

The decision to include censored observations and analyze these data using an obscure survival analysis technique may have confused some readers. As mentioned

Table 3. Comparison of Descriptive Statistics for Ventilator Failures, With and Without Censored Observations

	Mean hours before failure (with/without)	Median hours before failure (with/without)
CUB	13,257/12,983	13,203/14,833
STAR	6,927/5,490	4,849/3,686
VIP	6,996/5,351	4,999/3,743
6400ST	5,916/6,078	2,997/2,801
7200ae	10,749/8,700	8,973/5,304
8400STi	11,199/9,229	8,664/5,728
Total	8,950/7,562	5,842/4,844

CUB = Bear Cub Infant ventilator; STAR = Mallinckrodt Nellcor Puritan Bennett Infant Star ventilator; VIP = Bird VIP ventilator; 6400ST = Bird 6400ST ventilator; 7200ae = Mallinckrodt Nellcor Puritan Bennett 7200ae ventilator; 8400STi = Bird 8400STi ventilator.

previously, excluding censored data can bias a study's results; these data proved no exception. To demonstrate this fact, data gathered on the number of hours ventilators operated before experiencing a mechanical failure were analyzed twice. The initial analysis *included* the censored observations and the second analysis *excluded* the censored observations (Table 3). Using Table 3, several important inferences can be made. First, with only two exceptions, each brand of ventilator had a longer mean and median survival time when censored observations were included; thus, without the censored observations, we would have been misled into believing that the ventilators failed, on average, sooner than they actually did. By definition, a censored observation means the ventilator was still functioning at the conclusion of the study, and that the ventilator continued to function for an indeterminate additional period of time following conclusion of the study, which means that average survival time, including censored data, still *underestimates* the actual time before failure. An unexpected and statistically improbable finding made evident by Table 3 is that virtually all the comparisons (12 of 14, or 86%) exhibited longer mean (6 of 7) and median (6 of 7) times when the censored observations were included. If this finding is valid (ie, not a chance observation), then the data suggest that, on average, these ventilators were becoming less likely to fail as they aged. Collateral substantiation for this concept is found in two places: (1) the time series data, which shows that, despite increased utilization and age, ventilator malfunctions per month remained essentially constant throughout the study (see Fig. 4), and (2) the repair manual for the STAR, which specifically alludes to an "increased reliability with age."[13] The prospect that the measured time before failure of a ventilator might change as a function of time provides yet another reason for not placing too much emphasis on the exact times produced by this study. Moreover, if this information proves reproducible and accurate, hospitals could save money by maintaining ventilators longer before replacing them.

With new ventilators costing $30,000 or more, repairs $1,000 or more,[9,10] and with very high long-term maintenance costs (see Table 2), purchasing, owning, and maintaining a fleet of modern ventilators is a very costly proposition. Data such as these, if coupled with similar data gathered on other common ventilators, could eventually provide hospitals with a powerful tool for optimizing the dollars spent providing mechanical ventilation. It is surprising in this era of cost-containment that more administrators and institutions are not asking for unbiased, scientific comparisons.

These data also suggest that we have made little or no progress in reducing operator errors during mechanical ventilation. In this study, operator errors accounted for 38% (106 of 282) of reported malfunctions. This figure is quite comparable to two previous studies, in which operator or human errors associated with mechanical ventilation accounted for 40% and 31% of the total malfunctions, respectively.[14,15]

Human errors are potentially as dangerous as any type of malfunction,[7,8] yet they are the most preventable. These data represent a useful historical benchmark,[16] underscoring the need for improvements. If we are to reduce operator errors, particularly in an era preoccupied with cost-containment strategies, we must ensure that only conscientious practitioners with the necessary expertise are allowed to manage patients requiring ventilatory support. Should we fail to do so, a concomitant rise in the frequency and severity of operator errors seems inevitable.

Conclusions

In conclusion, these data suggest that most modern mechanical ventilators are rugged and safe. However, they are not comparable in terms of unexpected malfunctions. Furthermore, though ventilator malfunctions are to some extent inevitable, it appears that we have done very little over the years to limit or reduce the frequency of malfunctions. If hospitals considered unbiased, comparative, scientific data before deciding which ventilators to buy, substantial sums of money could be saved and malfunctions avoided. Modern ventilators also appear to become increasingly reliable the longer they are used, which is contrary to the popular notion that ventilators cost more to maintain as they age.[10] If these data can be validated, they may prove financially useful when considering whether to purchase new ventilators or continue to maintain older ones. Finally, the lack of unbiased scientific data of this type makes comparing and validating these data difficult, and suggests additional research and publication on the subject.

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PRODUCT SOURCES

Ventilators:

Bear Cub Infant Ventilator, Bear Medical Products, Thermo Respiratory Group, Yorba Linda CA

Bird VIP Ventilator, Bird 6400ST Ventilator, and Bird 8400STi Ventilator, Bird Medical Products, Thermo Respiratory Group, Yorba Linda CA

Mallinckrodt Nellcor Puritan Bennett 7200ae Ventilator, and Infant Star Ventilator, Mallinckrodt Nellcor Puritan Bennett Corporation, St Louis MO

Software:

Statistica for Windows 95/98/NT, version 5.1(M), StatSoft Inc, Tulsa OK

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APPENDIX

Analysis of Survival Data

Quantitative analysis of survival time data generally involves the determination of 2 related functions: the survivor function, and the associated hazard function. By definition, the survivor function, S(t), gives the probability that a ventilator survives longer than some specified time (t). Theoretically, as t ranges from 0 to infinity, graphs of survivor functions assume a smooth curve with the following characteristics: (1) they do not increase (ie, the proportion surviving always decreases as time increases); (2) at t = 0, S(t) = S(0) = 1, or because at the start of the study no ventilators have failed, the probability of surviving past t = 0 is 1; and (3) when t = infinity, S(t) = S(infinity) = 0, or if t is increased without limit, eventually no ventilator survives. The associated hazard function, h(t), is defined as the limit, as Δt approaches 0, of a probability statement about survival, divided by Δt (Δt represents a very small increment of t). Conceptually, the hazard function gives the instantaneous potential per unit t for the terminal event (failure) to occur, given that the ventilator has already survived up to t. As with the survivor function, hazard functions can be graphed with respect to t. However, unlike the survivor function, the related hazard does not have to start at 1 and decrease to zero. On the contrary, the hazard function can start anywhere, go up, down, or in any direction over t. Important characteristics of hazard functions are as follows: they are always ≥ 0, and they have no upper bound. Because S(t) provides us with quantitative information regarding survival and h(t) information about failure, then in some sense the hazard function can be considered as the negative side of information provided by the survivor function. Stated in practical terms, the higher S(t) for a given t, the lower h(t), and vice versa.

When analyzing survival data, the shape or form of the associated hazard function is used to determine the appropriate survival model. By definition, whenever the hazard function is constant [ie, h(t) = constant = b], the survival model is said to be exponential, ie, $S(t) = ae^{-bt}$ (a is a constant parameter of the distribution). For instance, imagine we studied the survival within a group of normal human subjects over a 2-year period. Because the subjects are all healthy, their risk of dying remains essentially constant throughout the course of the study; the associated hazard function would be constant and the best survival model would therefore be exponential. On the other hand, if the hazard function increases or decreases as a function of time, the survival model is referred to as either an increasing or decreasing Weibull model, respectively. If a hazard function first increases then decreases, the survival model is best defined as lognormal. The Weibull survival models are simply weighted exponential models of the form $S(t) = abt^{b-1}e^{-at^{b}}$, where a and b are constant parameters of the distribution. Algebraically, the Weibull model reverts to the exponential model whenever the b weight = 1.

The Impact of a Standardized Protocol for Placement of Indwelling Arterial Catheters

Erin M Ozgun MD, Charlie Strange MD, and Gerard A Silvestri MD MS

OBJECTIVE: To define the indications for placement of indwelling arterial catheters (IACs) in a medical intensive care unit, restrict placement to these indications, and assess the effect of this restriction on patient outcomes and laboratory utilization as a surrogate for cost. DESIGN: Prospective study. SETTING: Teaching hospital tertiary care medical intensive care unit. PATIENTS: Data were collected from 292 consecutive admissions from the Medical University of South Carolina (Charleston, South Carolina) Medical Intensive Care Unit. INTERVENTIONS: Indwelling arterial catheter placement was restricted to 4 indications identified in the literature. The mean number of arterial blood gases per admission, ICU length of stay, and ICU and hospital mortality were compared prior to and after IAC restriction. MEASUREMENTS AND MAIN RESULTS: Four indications for IAC placement were identified in the literature: (1) hypotension requiring vasopressor medications; (2) hypertensive emergency requiring rapidly-acting intravenous antihypertensives; (3) situations where blood pressure must be controlled within narrow limits (eg, controlled hypotension); (4) greater than 5 episodes of phlebotomy per day. Patient demographics, length of ICU stay, and ICU and hospital mortality were similar between control and IAC restricted groups. The number of IACs placed was significantly ($p = 0.004$) reduced from 39 in 133 control group admissions to 17 in 124 IAC restricted admissions. The mean number of arterial blood gases per admission was 7.0 in the control group and 5.6 in the IAC restricted group ($p = 0.23$). CONCLUSIONS: When IACs are restricted to published indications, the number placed is significantly reduced. The presence of an IAC alone does not influence arterial blood gas utilization. Critically ill patients who do not meet criteria for IAC placement can be safely managed without this technology. [Respir Care 1999;44(10):1193–1197] *Key words: arterial blood gas analysis, indwelling arterial catheter, blood pressure, laboratory utilization, critical care.*

Background

Escalating health care costs are a growing concern. It is estimated that intensive care medicine is responsible for 1% of the United States gross domestic product.[1,2] Although intensive care unit (ICU) beds account for only 7.5% of hospital beds, they are responsible for 20% of total hospital charges, with nearly one quarter of those attributable to laboratory services.[1–3] A previous study suggested that up to 50–60% of laboratory tests may be unnecessary at some teaching hospitals.[4] Reducing needless laboratory testing in the ICU significantly reduces costs without affecting mortality or length of stay.[5,6]

Indwelling arterial catheters (IACs) are commonplace in the United States. In a 1982 series of critically ill patients in France and the United States, IACs were placed 4 times more often and arterial blood gases (ABGs) were drawn more often in the United States, despite similar severity of illness and mortality statistics.[7] The concept that easy vascular access leads to more phlebotomy and laboratory testing is widely accepted as true.[8–10]

The aim of this study was to prospectively restrict IAC placement to indications found in a literature review, and assess the effect on laboratory utilization and patient outcome with a historical cohort of similar patients. Our hypothesis was that fewer arterial lines would be placed and the number of arterial blood gases would decline without affecting patient safety.

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Table 1. Indications for Indwelling Arterial Catheter Placement

1. Hypotension requiring vasopressor medications[11, 12, 13, 15]
2. Hypertensive emergency requiring the use of rapidly-acting parenteral antihypertensives[15, 16, 18, 19, 20]
3. Situations where blood pressure must be controlled within narrow ranges (eg, controlled hypotension)[15]
4. Greater than 5 episodes of phlebotomy per day[14, 17]

Methods

To identify the indications for IAC placement, the English language MEDLINE database was searched for all permutations of "blood pressure," "arterial," and "catheter" from 1977 to June of 1995. The citation list from relevant articles was reviewed to ensure inclusion of all indications for placement. Indications specific to the operating room were not included. Four indications for IAC placement (Table 1) were incorporated into the trial design.

A randomized, controlled trial design was dismissed because federal guidelines require that informed consent be obtained in any study in which it is possible, regardless of risk. Though possible, the reality of 24-hour-per-day informed consent in a population where surrogate consent is necessary promised a significant loss of patients, which would compromise the generalization of the findings.

As an alternative, 4 months of data on usual care were obtained prior to October 1, 1995, when an arterial catheter protocol was introduced. Follow-up data were gathered in the medical ICU for an additional 4 months. A waiver of informed consent was obtained for this study from the Medical University of South Carolina Institutional Review Board for Human Subjects.

Demographic data were collected on every admission to the medical ICU, including age, sex, presence of a central venous catheter, presence of mechanical ventilation, and acute physiology and chronic health evaluation (APACHE) III major disease category.[8] Severity of illness was documented by acute physiology score (APS),[8] APACHE III score,[8] and therapeutic intervention scoring system (TISS) score[7] during the first 24 hours of each ICU admission. All patients were monitored with automated oscillometric blood pressure cuffs and continuous pulse oximetry regardless of the presence of IACs.

Primary outcome data consisted of number of IACs placed and ABGs obtained during the ICU stay. Patients who had IACs placed outside of the medical ICU or had arterial sheaths placed by radiology or cardiology for specific procedures were excluded from both the control and post-implementation groups. Safety data obtained included ICU length of stay, ICU survival, and hospital survival.

APS, APACHE III, and TISS score, ICU length of stay, mean number of ABGs per admission, and age were expressed as mean ± standard error of the mean, and compared using the 2-tailed unpaired Student's *t* test. Sex, ICU and hospital survival, the presence of an arterial line during ICU stay, and the presence of a central line during the ICU stay were compared using chi-square analysis. APACHE III major disease categories prior to and after IAC restriction were compared using Fisher's exact test. A p value < 0.05 was considered significant.

Results

Two-hundred ninety-two consecutive admissions (252 patients) to the medical ICU were examined between June 1, 1995, and January 31, 1996. Twenty-two admissions in the control group and 3 in the IAC restricted group were excluded because IACs were placed outside of the medical ICU, usually in the operating room. Ten admissions were excluded in the control group because of missing data. One-hundred thirty-three admissions in the control group and 124 in the IAC restricted group were included in the statistical analysis.

Patients in the control and IAC restricted groups were similar in age, sex, APS, APACHE III, TISS, incidence of mechanical ventilation, and presence of a central venous catheter (Table 2). In the APACHE III major disease categories there were significantly more admissions classified as "other respiratory diseases" in the control group, and more admissions with neuromuscular diseases in the IAC restricted group. Otherwise the groups were similar.

Patient outcome is shown in Table 3. The number of IACs placed was significantly ($p = 0.004$) reduced, from 39 of 133 in the control group to 17 of 124 after IAC restriction (Fig. 1). The mean number of ABGs per admission was 7.0 in the control group and 5.6 in the IAC restricted group ($p = 0.23$). No difference in ICU length of stay, ICU survival, or hospital survival were measured.

Discussion

In the literature, we identified 4 major indications for IAC placement (see Table 1).[11–20] When IAC placement was prospectively restricted to these indications, we reduced the number of IACs placed by 56%, but found no difference in the number of ABGs between patient groups.

Smoller and Kruskall, in a retrospective study of phlebotomy practices, found that patients with IACs were phlebotomized twice as often as those without IACs,[10] although the patients were not risk-adjusted. Muakkassa et al retrospectively identified IACs as the strongest predictor of the number of ABGs drawn per patient in a surgical ICU. ABG number was independent of APACHE II score, arterial oxygen tension, arterial carbon dioxide tension, or the use of ventilators or pulse oximeters.[9] In an observa-

Table 2. Patient Demographics Before and After Restricting Indwelling Arterial Catheter Placement

	Control $n = 133$	IAC Restricted $n = 124$	P value
Mean age	50.9	53.2	0.31
Sex:			
male	73	60	0.36
female	60	64	
Mean APS	51.7	51.8	0.97
Mean APACHE III	62.8	62.5	0.94
Mean TISS	22.0	24.2	0.13
Mechanically ventilated	59	74	0.60
Central venous catheters	80	61	0.10
Central venous catheters in patients with IACs	37/39	14/17	0.31

IAC = indwelling arterial catheter. APS = acute physiology score (a severity of illness score that excludes chronic health issues). APACHE III = acute physiology and chronic health evaluation III score (a severity of illness score that includes some aspects of chronic health conditions). TISS = therapeutic intervention scoring system (a graded score of health care interventions provided).

Table 3. Outcome Following Indwelling Arterial Catheter Restriction

	Control $n = 133$	IAC Restricted $n = 124$	P value
ICU survival	81%	82%	0.95
Hospital survival	69%	69%	0.98
Mean ICU length of stay (days)	5.0 ± 0.5	3.9 ± 0.4	0.08
Mean ABGs per admission	7.0 ± 1.0	5.6 ± 0.7	0.23
Mean ABGs per admission in ventilated patients	13.9 ± 1.8	10.7 ± 1.5	0.39

IAC = indwelling arterial catheter. ICU = intensive care unit. ABG = arterial blood gas.

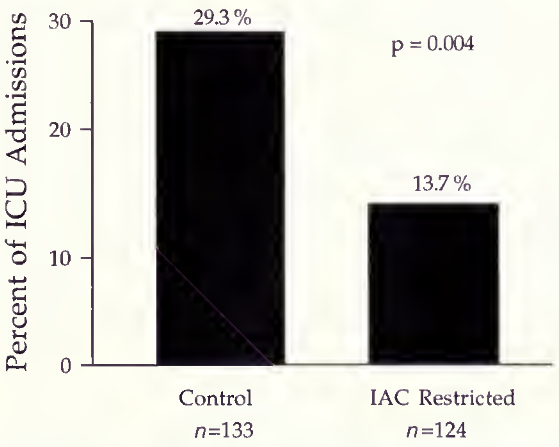

Fig. 1. Reduction in frequency of indwelling arterial catheter (IAC) placement after restriction to 4 indications identified in the literature. ICU = intensive care unit.

tional study, Low et al looked at this issue, controlling for severity of illness.[8] During the first 2 ICU days, patients with IACs had 30% more phlebotomy episodes and laboratory tests than patients without IACs. Although APACHE II scores were similar, most of the IACs were placed in the operating room, so that there were more surgical than medical patients in the IAC group. Subgroup analysis of surgical patients, however, confirmed their conclusion that patients with IACs had more episodes of phlebotomy and more laboratory tests than those without. The most common additional test in the IAC group, not surprisingly, was the ABG.

There is scant literature available on the indications for IACs. Although many reference texts offer a long list of indications, only a few are supported by scientific data. Most authors recommend 4–6 episodes of phlebotomy per day as an indication for IAC placement.[14,17] We chose 5 episodes of phlebotomy per day as a balance between IAC risks and the discomfort of repeated phlebotomy. Because there is little primary data on IAC indications, our list might be expanded in other patient groups. The only patient who fell outside our indications required continuous mean arterial pressure to standardize intracranial pressure monitoring equipment to calculate cerebral perfusion pressure in real time.

We selected ABG number as our indicator of lab utilization, for two reasons. First, ABGs have been shown to be the most sensitive measure of increased lab utilization in patients with IACs.[8,9] Second, other blood tests could easily be obtained from indwelling central venous catheters, which most of the patients with IACs had in place during their ICU stay. Interestingly, central venous catheter use was no higher when IACs were restricted.

In contrast to previous reports,[8–10] our results show no significant decrease in the number of ABGs when IAC placement is prospectively reduced. There may be several reasons for this difference. The current study controlled for both severity of illness and physician practice style. Since most previous studies have been performed in mixed populations of surgical and medical patients, differences in ABG number between ICU populations with and without IACs may be because of differences in physician practice styles, since most IACs are placed in surgical patients. All patients in the medical ICU were cared for by physicians trained in critical care medicine. All laboratory tests, including ABGs, required an order by the physician. Previous studies have shown that inappropriate ABG analyses can be significantly reduced by educating caregivers on the indications for ABG analysis.[21]

Restricting IACs to the indications identified in the literature significantly reduced catheter placement and probably total ICU costs. The cost of catheter placement and transducer maintenance was not studied. Although we did not observe any complications, these are well described and very real.[22] Also not studied were issues of nursing time, which probably balance between catheter maintenance and additional time obtaining blood in patients without IACs. In the current atmosphere of cost-containment, restricting IACs appears to be an effective means of reducing ICU costs without jeopardizing patient care.

There are a number of limitations to this study. Foremost, it was not randomized or blinded. Although control data were gathered without the awareness of practitioners in the ICU, all were aware of the ongoing study during the IAC restriction. However, if physicians changed their diagnostic testing during the IAC restricted period, we would expect them to be more conservative. The impact of monthly differences in house staff at different times of the year adds additional variance that was minimized by ICU education about the protocol.

There may have been some differences in the two patient populations. Minor differences in the APACHE III major disease classifications exist between the control and IAC restricted groups, but these are probably not clinically important. These differences were in the causes of respiratory failure, but were not reflected in total number of patients ventilated.

The last limitation is the relatively small number of IACs placed in either group. ABG numbers were averaged from the entire cohort during the entire ICU stay. In many cases the time during which an IAC was in place may have been relatively short compared to the total ICU stay. Thus, numerous ABGs were drawn in the absence of an IAC. Nonetheless, despite studying a large number of patients, we failed to identify a practical difference in frequency of ABG analysis after reducing IAC placement by more than 50%. Of note, there were no subgroups, including ventilated patients, where limiting IACs reduced ABG numbers.

A power analysis performed on our data set suggests that future studies attempting to measure differences in ABG number would require 1,034 patients, with an α of 0.05 and β of 0.10. To detect changes in ICU mortality at the same levels of significance, assuming that 1% of patients might have mortality influenced by IAC placement, would require 35,000 patients. We feel it is unlikely that these studies will be performed.

Conclusions

This study has several implications. Although there are relatively few well-defined indications for IAC placement, we identified 4 from the literature that allowed IAC restriction to be effective and probably cost saving. Furthermore, noninvasive technology such as indirect automatic oscillometric blood pressure monitoring, pulse oximetry, and indirect CO_2 monitoring increasingly replace the need for many IACs.

Indwelling arterial catheters may not independently contribute to increased lab utilization in the medical ICU, as was previously thought. This finding will certainly vary with practice style and should be studied in other intensive care settings. This study suggests that a cost control strategy addressing the indications for individual tests rather than limiting easy vascular access may also be a worthwhile alternative.

In summary, there has been an explosion in the use of invasive technology in the critical care setting that diffuses into practice without rigorous assessment. This study has found that there are few indications for IACs. We conclude that indwelling arterial catheters should be placed only for the indications outlined in this study for medical ICU patients.

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Analysis of Failure Time Data: An Introduction to Survival Analysis

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Many studies in clinical medicine are designed to address whether a new procedure or treatment will perform better than those currently available. Outcomes in such clinical studies often include short-term effects such as the length of hospitalization, and may include long-term outcomes such as major morbidity and mortality. The identification of risk factors related to the outcome is also of great interest in such clinical investigations. For example, a clinical investigator may be interested in examining if a procedure, such as lung volume reduction surgery for chronic obstructive pulmonary disease, increases patient survival, and whether specific patient factors are associated with improved survival. The primary outcome or response variable in such a study is the time between the surgery and the patient's death. Factors that can alter the outcome include the patient's age, current use of corticosteroids, and the patient's functional status prior to surgery. The analytical methods for such data are often referred to as "survival analysis." Although these techniques are frequently used in studies where mortality is the outcome of interest, the methods are not confined to the event of death, but are used for any type of event. The article by Blanch in this issue of Respiratory Care illustrates the utility of these methods in comparing malfunction and mechanical failure rates of several ventilator brands.[1] The purpose of this article is to describe these techniques in some detail and allow the reader to gain some appreciation for this analytical approach.

Probability Functions for Failure Time Data

Failure time is generally defined as the time to the occurrence of a specific event.[2–4] Survival time, on the other hand, is defined as the time during which there is an absence of an event (eg, death). "Survival" and "failure" time differ in that survival to a time *t* refers to the absence of death up to that time whereas failure time refers to the time until the occurrence of an event. Examples of failure times are the time to relapse of a malignancy and the time to institution of supplemental oxygen in severe emphysema. For the purpose of this discussion, we will use the term "survival" to signify the generic absence of a specific event.

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Before illustrating the methods, let us consider the reasons why special methods are necessary for the analysis of survival data. First, because of time and cost limitations, investigators conducting longitudinal studies often cannot follow study participants indefinitely. Analysis of outcome data are often necessary at certain time points during the study or at the end of the study period. It is, therefore, certainly possible that not all of the participants have experienced the event of interest. Survival time for participants who have experienced the event at or before the time of analysis is defined as the time from the enrollment into the study to the occurrence of the event. These observations are referred to as uncensored observations.[2–4] Survival time for participants who have not experienced the event at the time of the analysis is not exactly known, because not enough time has passed for the event to occur. These observations are called censored observations.[2–4] Moreover, participants who either withdraw from the study prior to its completion or are lost to follow-up for other reasons are also considered as censored observations since their exact survival times are not known. Classical statistical methods such as regression analysis must truncate, eliminate, or randomize censored observations and can therefore bias or introduce error into the analysis. Survival analysis circumvents this problem of censored data and allows the use of data from censored and uncensored observations.

The second reason for the need of special methods to analyze survival data is to allow for the time-dependent nature of potential risk factors or prognosticating variables. For example, to investigate the role of cigarette

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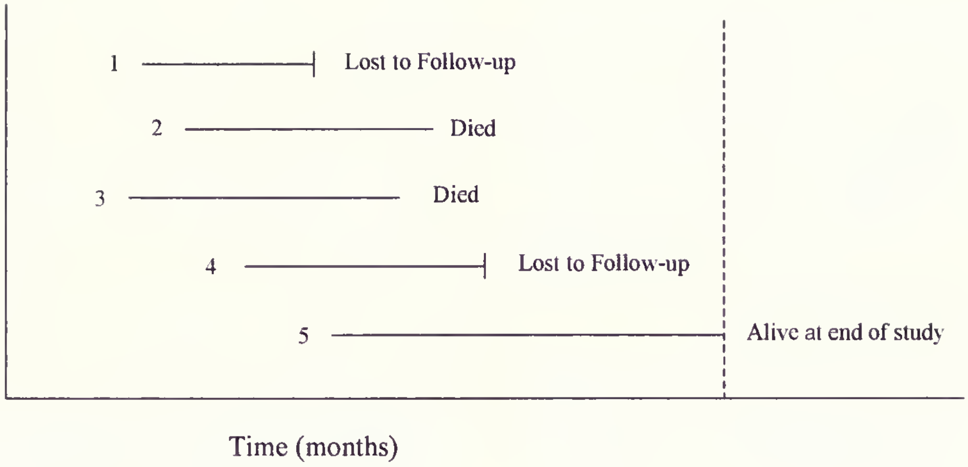

Fig. 1. Hypothetical example of survival data.

Table 1. Survival Data for Patients After Coronary Angioplasty

Patient ID	A	B	C	D	F	G	H	I	J	K
Survival time (years)	4	3+	10	3	1	2	6	7+	5	3

smoking on the time to development of lung cancer, it is imperative to consider not only the amount of cigarette smoking by a particular individual, but also the temporal sequence of his or her smoking. Patients start and stop smoking at various points in their lives, and it is certainly possible that cumulative exposure and temporal sequence are equally important. Therefore, we need to have the ability to incorporate the time-dependent nature of such variables to determine their predictive value for a particular outcome (eg, lung cancer).

The third reason for the need of special methods is that not all participants in a study enroll at the same time. Figure 1 shows an example of 5 patients enrolled in a study of a new anticancer drug for lung cancer. In this hypothetical example, Patients 1 and 4 withdrew from the study prior to completion and were lost to follow-up. Patient 5 was alive at the end of the study. All 3 of these are considered as censored observations. Patients 2 and 3 died during the study period, and their survival times are recorded. Given the uncertainties of how patients can enter and exit the study, the technique of survival analysis was developed to efficiently utilize all of the available data.

As mentioned previously, survival times are data that measure the time to an event. Observed survival times (T) are subject to random variations and form a distribution that is expressed as a function of time (t). Three probability functions are used to characterize the distribution of survival times: (a) the survivorship function; (b) the probability density function; and (c) the hazard function.[2–4] The survivorship function, denoted as $S(t)$, represents the probability (P) that an individual survives longer than time t. Using probability notation, the function $S(t)$ is written as:

$$\begin{aligned} S(t) &= \text{P (an individual survives longer than } t) \\ &= \text{P}(T > t) \end{aligned}$$

From the definition of survival and failure times, we can also express $S(t)$ as a function of the failure time $F(t)$.

$$\begin{aligned} S(t) &= 1 - \text{P (an individual fails before time } t) \\ &= 1 - F(t) \end{aligned}$$

To depict the course of survival, $S(t)$ is often graphically displayed, and the plot is referred to as the survival curve. In clinical studies, these curves are plotted against time and decay with increasing follow-up time. The most common approach to estimate the survivorship function is the Kaplan and Meier product-limit method.[5] Consider, for example, the survival times shown in Table 1, a hypothetical clinical study designed to measure survival after coronary angioplasty.

The observed times for censored observations are denoted by a plus sign (+). Within this cohort, two patients (B and I) were followed for 3 and 7 years, respectively, but then were lost to follow-up. All other patients were followed until death. At the initiation of the study (time zero), all of the patients are alive. Therefore, the survivorship

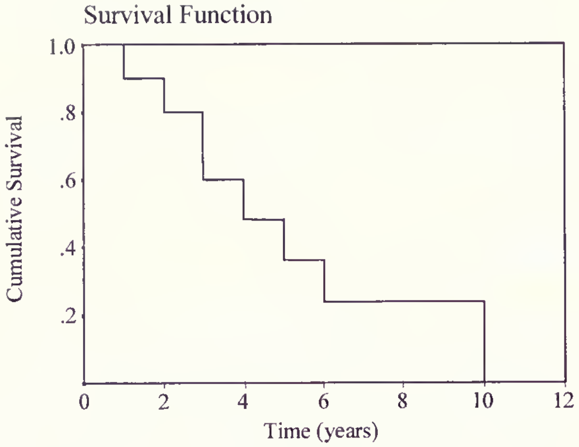

Fig. 2. Survival function for hypothetical coronary angioplasty outcome data.

function at time zero $S(0)$ is equal to 1.0. At the first year follow-up, 1 patient had died, and 9 of the 10 survived past 1 year, so $S(1) = 9/10$ or 0.9. At the two-year follow-up, another patient had died. The probability of surviving through the second year was 8/9, as there were only 9 patients at risk during this time period and 8 survived. To determine the cumulative probability of surviving through two years, we need to take the product of the probability of survival at Year 1 and 2, which is $S(1) \times S(2)$. Thus at each time t_i, the survivorship function is the product of the previous survival probabilities and the probability of surviving beyond t_i. Using general notation, $S(t)$ for a particular time t_i is expressed as:

$$S(t_i) = \prod_{t_j \le t_i} \frac{(n_j - d_j)}{n_j}$$

where n_j represents the number of patients at risk who have survived up to time j, and d_j represents the number that have died during the time between t_j and t_i. Censored observations are included in n_j prior to the censoring, but not after. For the data given in Table 1, Patient B would be included in the determination of the survivorship function up to 3 years, and $S(3)$ would be $9/10 \times 8/9 \times 6/8 = 0.6$. To determine $S(4)$, Patient B would not be included in the number at risk (n_j), because the follow-up time for this patient was only 3 years. Figure 2 shows the survivorship function plot versus time for this data. Two or more survival curves can be plotted simultaneously to compare groups of patients that differ with respect to a variable of interest (eg, gender, smoking, or race) to assess whether there is any difference between these groups. Several statistical tests (eg, log-rank or the generalized Wilcoxon test) can then be employed to determine whether the survival curves are statistically different.[2–4]

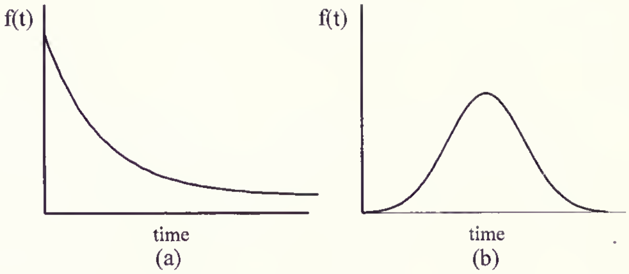

Fig. 3. Two examples of density functions.

The second probability function basic to survival analysis is the probability density function, symbolized as $f(t)$. This function represents the probability that an individual fails in a short interval from t to $(t + \Delta t)$ per unit width Δt. It is expressed as:

$$f(t) = \lim_{\Delta t \to 0} \frac{P\{\text{failure in the interval } (t, t + \Delta t)\}}{\Delta t}$$

The probability density function describes the pattern of failure rate as a function of time, and is the derivative of the cumulative distribution function $F(t)$ with respect to time, or dF/dt. The density function enables us to determine the proportion of failures in any time interval, and to examine the frequency pattern of failure rate. Figure 3 shows two examples of a probability density function: figure 3a shows a pattern of high failure ráte at the beginning of the study, and Figure 3b shows a peak in failure rate at the midpoint of the observation period.

The third probability function is the hazard function, which is defined as the probability of an individual failing during a short interval from t to $(t + \Delta t)$ per unit of time, given that the individual has survived to time t:

$$h(t) = \lim_{\Delta t \to 0} \frac{P\{\text{an individual of age } t \text{ fails in the interval } (t, t+\Delta t)\}}{\Delta t}$$

The hazard function is also called the conditional failure rate or the force of mortality. Unlike the survivorship function $S(t)$, the hazard function represents the failure rates for only those individuals who have survived up to a particular time. The three probability functions defined above are mathematically related and can be derived from each other. Given one function, the other two can be determined. For example, the hazard function can also be defined in terms of the probability density function and the survivorship function.

$$h(t) = \frac{f(t)}{\{1 - f(t)\}} = \frac{f(t)}{S(t)}$$

Since $f(t)$ is a derivative of $[1 - S(t)]$, we can write $h(t)$ as:

$$h(t) = \frac{-dS/dt}{S(t)}$$

Integrating both sides of the above equation yields

$$-\int_0^t h(x)dx = \ln[S(t)]$$

Solving for $S(t)$, we have

$$S(t) = \exp\{-\int_0^t h(x)dx\}$$

The hazard function is central to the technique of survival analysis, and forms the basis for the developing models of survival time.

Several well-known distributions have been used in the description of survival times. Some of the commonly-used distributions include the exponential distribution, the Weibull distribution, the lognormal distribution, and the γ distribution.[2–4] We will briefly focus on the exponential distribution, which is the simplest and the most common in survival studies. When the survival times follow a one-parameter exponential distribution, the survivorship function takes the form:

$$S(t) = e^{-\alpha t}$$

where α is a constant parameter. Since the cumulative distribution function $F(t)$ is equivalent to $1 - S(t)$, we can write the probability density function as:

$$f(t) = \alpha e^{-\alpha t}$$

As noted above, the hazard function can be expressed as a ratio of the density function and survivorship function $[f(t)/S(t)]$. When distribution of survival times takes an exponential form, the hazard is a constant, and independent of t.

$$h(t) = \frac{f(t)}{S(t)} = \frac{\alpha e^{-\alpha t}}{e^{-\alpha t}} = \alpha$$

To determine whether a set of observed data come from an exponential distribution, we can plot $\log_e S(t)$ against time. A linear configuration of this plot would suggest that the data follow an exponential distribution. Though the hazard function in this situation is a constant, that is not generally the case. The hazard function can progressively increase, decrease, or take on a complex form. For example, patients with metastatic carcinoma refractive to chemotherapy have an increasing hazard function (increasing risk of death), whereas patients with a carcinoma in situ that has been resected have a decreasing hazard function (risk of death decreases over time).

The Proportional Hazards Model

As mentioned above, there are several tests (eg, log-rank test, generalized Wilcoxon test, Cox-Mantel test, and Mantel-Haenszel test) available to determine whether two or more survival curves differ significantly.[2–4] We may, for example, want to examine whether there is a difference in the all-cause mortality between smokers and nonsmokers. These statistical tests can be used to assess whether the observed differences in the survival curves for 2 or more groups are significant or merely due to chance. However, this approach requires that the data be stratified on different levels of the key exposure variable. Though this can be very useful when there are a small number of strata, alternative methods are needed when there are many strata or if there are several risk factors of interest. A more convenient approach is to use the method of regression analysis for survival data. Several different models can be used to relate survival time data to a collection of risk factors. One of the most frequently used models was proposed by Cox[6] and is known as the proportional hazards model. Under the proportional hazards model, the hazard function is modeled as

$$h(t|x_1, x_2, \ldots, x_k) = h_0(t)\exp\left(\sum_{i=1}^{k} \beta_i x_i\right)$$

$$= h_0(t)\exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k)$$

where $x_1, x_2, \ldots, x_k$ are a collection of independent variables, $h_0(t)$ is the baseline hazard function with a value of zero for all of the independent variables (x_i), and the β_i are the regression coefficients. The proportional hazards model assumes that the hazard function across categories of the independent variable is proportional to that of the underlying hazard function, and independent of time. With algebraic manipulation, the above expression is equivalent to

$$S(t) = [S_0(t)]^{\exp(\sum_{i=1}^{k} \beta_i x_i)}$$

Thus, the survival for any set of covariates x_i can be calculated from the baseline survivorship function $S_0(t)$ by raising it to the power of the exponential term with specific values for x_i. In order to determine the regression coefficients, we take the natural logarithm of both sides of the hazard function $h(t)$.

$$\log_e\left[\frac{h(t)}{h_0(t)}\right] = \sum_{i=1}^{k}\beta_i x_i = \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k$$

If we let the left-hand side of the above equation equal y_i, we obtain a standard multiple-regression equation with x_i as the independent variable and a function of the hazards as the dependent variable. The above expression also allows us to interpret the coefficients of the proportional hazards model in a way similar to that of multiple logistic regression. That is, the quantity $\exp(\beta_i)$ represents the ratio of hazards of two individuals, one with the exposure of interest and the other without, given that the individuals have the same values for all other covariates. This ratio, commonly referred to as the hazards ratio or relative risk, can be used to compare two or more groups of subjects who differ with respect to a covariate (eg, treatment, procedure, or risk factor). Commercially available software packages estimate the hazard ratios using the conditional log-likelihood method, which is discussed by Lee.[4]

Although the proportional hazards model is commonly used, several alternative survival models exist. Since the Cox model assumes a proportional hazard, it is often described as a semi-parametric model, since it does not depend on a specific functional form of $S(t)$ or $h(t)$. The analysis is based on examining the effects of the independent variables on the relative hazards without any reference to the baseline hazard. In contrast, parametric proportional hazards models[2–4] specify the baseline hazard either as a constant or as a function of time (eg, Weibull, Gompertz, or log-logistic).

Conclusions

Special methods are needed to analyze data from studies of failure time because censored observations occur when study participants enter and exit the study at various time points or the study period is not long enough to observe all of the potential events. The techniques of survival analysis enable us to utilize all of the available information, irrespective of whether the observations are censored or uncensored. Survival curves are routinely drawn using the Kaplan and Meier product-limit method and compared across categories of an exposure variable to determine whether there is any statistically significant difference between groups. Moreover, the effect of several risk factors on failure time can be simultaneously examined with multivariate survival models. As we develop new treatment alternatives and/or investigate the failure of specific clinical approaches or medical devices, the method of survival analysis will need to be an integral part of our analytical approach. Furthermore, these techniques will remain an invaluable asset in our search for time-dependent and independent risk factors that are associated with the occurrence of specific failures or events. With the advancements in the theoretical background for these techniques and the availability of software packages to perform these analyses, we will continue to see a diverse application of these methods in analysis of failure time data.

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An 82-Year-Old Man with Amyotrophic Lateral Sclerosis

Loutfi S Aboussouan MD

Case Summary

An 82-year-old man presented to the pulmonary clinic with a 2-year history of orthopnea, as well as shortness of breath. At the time of presentation the patient also had significant dysphagia, and a percutaneous endoscopic gastrostomy feeding tube had been inserted. About a month earlier, electromyographic studies were consistent with a diagnosis of motor neuron disease of the amyotrophic lateral sclerosis (ALS) type. He had been a 15 pack-year smoker, but had quit 30 years earlier. He had no history of asthma, emphysema, or bronchitis. Table 1 shows the results of spirometry at the time of presentation, and a full pulmonary function survey done 5 months earlier.

1. What is the interpretation of this pulmonary function survey?
2. With what disease is this pulmonary function survey most consistent?

Table 1. Results of Screening Spirometry on an 82-Year-Old Man with Amyotrophic Lateral Sclerosis

Test	Predicted	5 Months Earlier		Current	
		Measured	% Predicted	Measured	% Predicted
FVC (L)	4.01	1.86	46	1.52	38
FEV_1 (L)	3.02	1.66	55	1.17	39
FEV_1/FVC	0.76	0.89	—	0.76	—
TLC (L)	6.68	5.52	83	—	—
RV (L)	2.55	3.50	137	—	—
FRC (L)	3.60	4.33	120	—	—

Predicted = Mean predicted values per Crapo et al.[1]
FVC = Forced vital capacity.
FEV_1 = Forced expiratory volume in the first second.
FEV_1/FVC = Ratio of FEV_1 to FVC.
TLC = Total lung capacity by helium dilution (liters).
RV = Residual volume (liters).
FRC = Functional residual capacity (liters).

Discussion

There is a rapid decline in the forced vital capacity over a period of 5 months, consistent with a progressive restrictive pulmonary impairment due to ALS. However, the total lung capacity (TLC) appears to be well preserved on the earlier test, despite a significant reduction in both forced expiratory volume in the first second and forced vital capacity. Other findings include an elevation in residual volume (RV), and functional residual capacity (FRC) at the upper limit of normal.

The pattern of change in absolute lung volumes can be useful in suggesting the type of restrictive process.[2] The specific patterns of change in lung volumes noted in ALS are as follows:

Total Lung Capacity. In neuromuscular diseases such as ALS, the vital capacity (VC) often falls below normal limits, but TLC is usually preserved until relatively late in the course of the illness.[3,4] Two factors may explain this finding:

(1) The patchy nature of ALS may result in fairly preserved diaphragmatic function. Inspiratory muscle strength is a major determinant of TLC. The other 2 determinants, namely elastic recoil of the lung and to a lesser degree of the chest, are both expected to be fairly preserved in neuromuscular disease. In a study of 32 patients with ALS, maximal inspiratory pressures were found to be significantly higher than maximal expiratory pressures (62% vs 37% of predicted, respectively).[4]

(2) The shape of the relaxation pressure-volume curve of the respiratory system may indicate that a decrease in inspiratory muscle strength is accompanied by a comparatively much smaller decrement in TLC.[4]

As a result, decreases in maximal inspiratory pressures do not correlate,[5] or correlate weakly,[6] with changes in TLC and VC.

Vital Capacity and Residual Volume. Expiratory muscle strength is a major determinant of RV (the other determinant being elastic recoil of the chest). Studies of ALS

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patients have shown a strong negative correlation between maximum static expiratory pressure and RV.[4] Thus, the RV is often increased in neuromuscular disease affecting the expiratory muscles.[2–4] As a result, the VC (TLC – RV) is decreased predominantly from an increase in RV, and, to a lesser degree, a decrease in TLC.

Functional Residual Capacity. The FRC in ALS patients is often slightly increased or at the upper limit of normal.[3,4] The major determinants of FRC are the inward elastic recoil of the lung balanced by the outward elastic recoil of the chest. Therefore, the FRC tends to be unaffected by neuromuscular disorders.[2] It has been speculated that decreased abdominal tone in ALS results in a passive descent of the diaphragm and produces the small increase in FRC.[4]

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A 59-Year-Old Man with Gradually Increasing Dyspnea

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Case Summary

The patient was a 59-year-old male who was evaluated for gradually increasing dyspnea on exertion for 4 years. At the time of evaluation, he could walk approximately a half block on flat ground and climb one flight of stairs before having to stop to catch his breath. He had a mild, nonproductive cough. There was no history of hemoptysis, paroxysmal nocturnal dyspnea, weight loss, orthopnea, chest pain, or exposure to birds, molds, or mildew. He had worked in fiberglass molding for 10 years, and before that in a foundry for 15 years.

On examination, the patient was in no apparent distress, and vital signs were stable. He had early clubbing of his fingers. No cyanosis, anemia, or pedal edema was noted. The lungs revealed coarse inspiratory crackles in both lung bases halfway up posteriorly. Cardiovascular examination was normal, without murmurs or rubs. A chest roentgenogram showed diffuse, bilateral, peripheral interstitial disease. A computed tomography scan of the chest revealed interstitial disease with peripheral and lower zone predominance. Some traction bronchiectasis and basilar honeycombing were also seen. Table 1 shows the results of pulmonary function testing.

What is your diagnosis?

Table 1. Results of Screening Spirometry for a 59-Year-Old White Man with Gradually Increasing Dyspnea

Test	Predicted	LLN	Measured	% Predicted
FVC (L)	4.85	3.53	2.86	62
FEV_1 (L)	3.66	2.81	2.37	65
FEV_1/FVC	0.79	0.70	0.83	106
$FEF_{25-75\%}$ (L)	3.48	1.82	2.77	80
FRC (L)	3.56	2.58	2.81	79
RV (L)	2.37	1.70	1.48	62
TLC (L)	6.85	5.24	4.64	68
RV/TLC (%)	32	23	32	99
D_{LCO} (ml/mm Hg/sec)	25.3	19.6	11.6	46
D_L/V_A (ml/mm Hg/sec)	4.72	3.46	2.64	56

Predicted = Mean predicted values per Crapo et al.[1]
LLN = Lower limit of normal, the value as the lower fifth percentile of the normal range.
FVC = Forced vital capacity.
FEV_1 = Forced expiratory volume in the first second.
FEV_1/FVC = Ratio of FEV_1 to FVC.
$FEF_{25-75\%}$ = Forced expiratory flow between 25% and 75% of FVC.
FRC = Functional residual capacity.
TLC = Total lung capacity by helium dilution.
RV = Residual volume.
D_{LCO} = Diffusing capacity for carbon monoxide.
D_L/V_A = Ratio of diffusing capacity to alveolar volume.

Discussion

On the spirometry, the preserved FEV_1/FVC ratio (forced expiratory volume in the first second over forced vital capacity) and decreased FVC suggest a restrictive ventilatory defect. Lung volumes show decreased functional residual capacity, residual volume, and total lung capacity, verifying the presence of restrictive physiology. The diffusing capacity of the lung for carbon monoxide is severely reduced and does not correct when adjusted for alveolar volume, indicating a parenchymal defect. All these findings point to a pure parenchymal restriction (eg, idiopathic pulmonary fibrosis).

A restrictive pattern may be seen on pulmonary function testing in a variety of disorders. It is most useful to divide these into (1) parenchymal restriction (eg, interstitial lung diseases) and (2) extraparenchymal restriction (eg, neuromuscular impairment, severe chest wall and/or vertebral column deformities, morbid obesity, and pleural diseases). Pulmonary parenchymal inflammation and fibrosis cause the lungs to be "stiffer"[2] (ie, increased elastic recoil, decreased compliance). Measured lung volumes will be lower than expected because the tendency for the lung to "deflate" (ie, recoil) will be greater than expected.[3] For instance, functional residual capacity, which represents the point at which the elastic recoil forces of the lung are balanced by the tendency of the chest wall to expand, will be low because of the abnormally high recoil force. Further, because of the increased recoil force, the FEV_1/FVC ratio may be supranormal.[4] Finally, because the inflammation and fibrosis involves the gas exchange units of the lung, the diffusing capacity of the lung for carbon mon-

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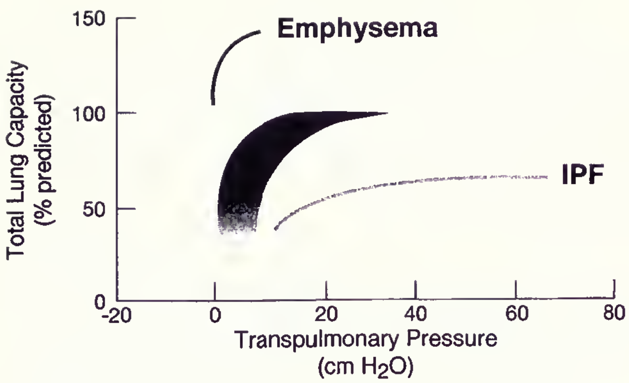

Fig. 1. Pressure-volume curve of pulmonary compliance.

oxide will also be reduced. This last finding is important because it helps to distinguish parenchymal restriction from extraparenchymal disorders that may result in reduced lung volumes. In disorders such as obesity or neuromuscular weakness, where the gas exchange units of the lungs are not affected, the ratio of diffusing capacity to alveolar volume (D_L/V_A) is expected to be normal.[5]

When there is a question as to whether the observed restriction represents parenchymal or extraparenchymal disease, a pressure-volume curve may help (Fig. 1). For this test, an esophageal balloon is placed to help measure transpulmonary pressure. The patient is asked to take a deep breath, to total lung capacity, and then to slowly exhale. Static transpulmonary pressure is measured at numerous lung volumes during the maneuver, and a curve is generated to plot the relationship of the transpulmonary pressure (on the X-axis) to the lung volume (on the Y-axis). In both parenchymal and extraparenchymal restriction, the lung volumes measured at any particular transpulmonary pressure will be lower than expected, resulting in a curve shifted downwards and to the right. However, the curve will maintain a normal slope in extrapulmonary disorders, whereas the slope will be decreased (the curve will be "flatter") in parenchymal disorders such as idiopathic pulmonary fibrosis.[6]

This patient underwent an open lung biopsy, which showed pulmonary fibrosis consistent with a diagnosis of idiopathic pulmonary fibrosis.

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Capnography in a Double-Lung Transplant Recipient with Respiratory Failure

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A 33-year-old female patient underwent bilateral lung transplant for pulmonary hypertension, and had a prolonged hospital course because of bacterial pneumonia and acute rejection, diagnosed by bronchoscopy. Prior to discharge (postoperative day 40), a surveillance bronchoscopy revealed patent airway anastomoses, but pulmonary function studies were not obtained because the patient had a healing tracheotomy site. She presented to clinic on postoperative day 60 complaining of dyspnea and a nonproductive cough that had developed over 7–10 days. Physical examination revealed a restless, afebrile patient with a respiratory rate of 26 min^{-1} and a heart rate of 90 min^{-1}. Auscultation of the lungs revealed crackles in the left and right upper lung fields and diminished breath sounds in the right lower lobe. An arterial blood gas measurement revealed a pH of 7.43, an arterial carbon dioxide tension of 35 mm Hg, and an arterial oxygen tension of 68 mm Hg (oxygen at 2 L/min). A chest radiograph showed diffuse bilateral interstitial infiltrates, a left lower lobe infiltrate, and a radiolucent right lower lobe. Concern regarding the etiology of the infiltrates led to a bronchoscopy with transbronchial biopsies. An endotracheal tube was placed at the time of bronchoscopy, and a capnogram was obtained using a mainstream carbon dioxide analyzer (Fig. 1).

1. Which segment of the capnogram is abnormal?
2. What are the potential causes of this pattern?

The capnogram shows a normal-appearing Phase 1 and Phase 2, but Phase 3 is abnormal, displaying a biphasic contour. The biphasic contour represents lung regions emptying at different rates, revealing different time constants.

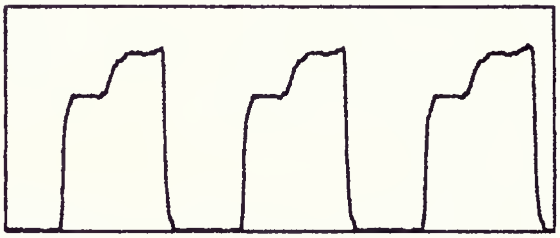

Fig. 1. Capnography tracing from a double-lung transplant recipient during a bout of acute respiratory failure due to pneumonia and rejection.

Time constants are the product of airway resistance and lung compliance. In Figure 1 there appears to be a group of lung units with a short time constant (first plateau) and a group with a longer time constant (second plateau). Increases in the slope of Phase 3 have been described in patients with airway obstruction such as asthma,[1] and bronchodilator administration reverses the slope change.[2] Capnography allows monitoring of physiologic variables pertaining to pulmonary perfusion and airway flow. In this case the biphasic capnogram represents uneven gas emptying such that the respiratory system behaves as a 2-compartment model. Patients with severe obstructive lung disease (eg, emphysema) receiving a single-lung transplant have been found to exhibit biphasic capnograms[3] or spirograms[4] in the absence of an airway complication. In a lung transplant recipient, a biphasic spirogram may indicate the development of stenosis at the anastomosis, acute rejection, or bronchiolitis obliterans.[5] Airway complications have become less prevalent with improvements in surgical technique, maintenance immunosuppression, and rejection surveillance.[6]

Bronchoscopy revealed bilateral patent anastomoses, and a narrow, edematous bronchus intermedius was identified, with a luminal diameter < 3 mm (normal ~ 12 mm), such that the right middle and lower lobe segments could not be visualized. Transbronchial biopsies of this region showed evidence of acute rejection (Grade II), obliterative bronchiolitis, and cytomegalovirus pneumonia. The patient subsequently developed respiratory failure requiring mechan-

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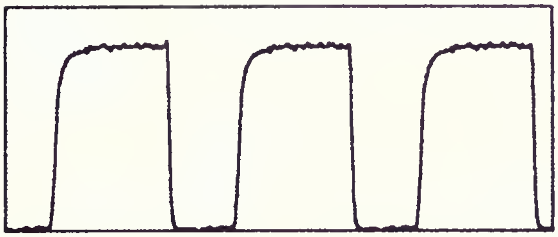

Fig. 2. Capnography tracing from a double-lung transplant recipient 5 weeks after treatment of pneumonia and rejection.

ical ventilation. The rejection was aggressively treated with augmented immunosuppressive therapy consisting of intravenous pulse steroids, tacrolimus (Prograf), and plasmapheresis. Intravenous ganciclovir was administered for treatment of cytomegalovirus pneumonia. Symptoms gradually improved over 5 weeks, and the patient was released from the hospital.

Prior to discharge, a chest radiograph revealed resolution of the left lower lobe infiltrate, and an arterial blood gas measurement indicated a pH of 7.39, an arterial carbon dioxide tension of 36 mm Hg, and an arterial oxygen tension of 73 mm Hg (room air). Pulmonary function data were not available at this time. Follow-up bronchoscopic evaluation revealed a patent, nonedematous, normal-appearing bronchus intermedius, and transbronchial biopsies showed no histologic evidence of acute rejection or pneumonia. A capnogram was obtained at the time of the bronchoscopy (Fig. 2).

Are there any abnormalities in the capnogram in Figure 2?

No. Figure 2 shows the patient's capnogram, and Figure 3 is an illustration of a normal capnogram. The capnogram can be divided into 4 segments that correspond to distinct phases of the respiratory cycle. The first phase is the flat part of the capnogram, corresponding to inspiration. The second phase is the ascending segment, corresponding to exhalation of CO_2 from the upper airways. The third phase is the plateau or top flat portion of the tracing that represents exhaled CO_2 from the lower airways and alveoli. The fourth phase is the descending curve, representing the initiation of inspiration, when fresh (CO_2-depleted) gas passes over the sensor.[7]

Identification of a biphasic capnogram in a double-lung transplant recipient should alert the clinician to the development of an airway complication at the anastomosis or elsewhere, because the capnogram should be of normal shape and contour after this type of surgery. In this case, narrowing of the bronchus intermedius was due to airway inflammation brought about by acute allograft rejection and cytomegalovirus infection, which led to the development of a biphasic capnogram. Resolution of the airway narrowing was achieved by treating the rejection and cytomegalovirus infection, and bronchoscopy confirmed the widening of the airway lumen. Improvements in the caliber of the right lower lobe corresponded with loss of the biphasic contour of Phase 3. The patient's clinical condition continued to improve such that she was liberated from the ventilator and discharged from the hospital.

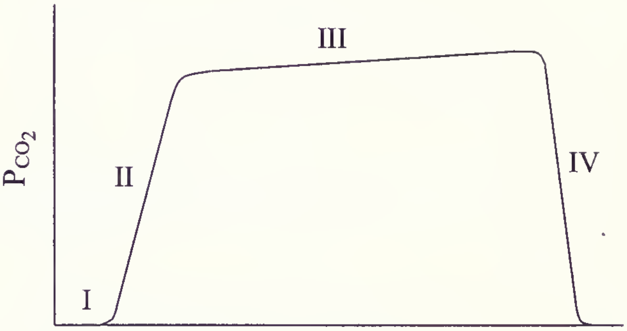

Fig. 3. A normal capnogram, with the labeled segments corresponding to the different phases of the respiratory cycle.

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Letters

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A Medical Myth

In the August 1998 issue of RESPIRATORY CARE, the Point of View position paper by John Salyer RRT[1] and the editorial response by Charles G Durbin Jr MD[2] are both well-written and well-argued viewpoints. Both authors, however, repeat the myth that only 10–20% of medical interventions have demonstrated efficacy.

It is true that the U.S. Office of Technology Assessment (OTA) has stated these figures regarding efficacy on at least 2 occasions,[3,4] but a recent reading of these papers and their references leads me to the conclusion that the 10–20% figure should not be taken seriously. Dr Kerr L White, a noted epidemiologist, was the ultimate source of these figures, in the mid-1960s, at a seminar held at Johns Hopkins on the application of epidemiological methods to the evaluation of health services. As a member of the Health Advisory Panel to the OTA, Dr White repeated the 10–20% figure in 1976 and invited others to provide more recent data. No one was able to do so, and the OTA repeated his numbers.[5]

Dr White arrived at his 10–20% figures based on a 2-week survey published in 1963[6] of 19 general practitioners in a northern British industrial town. The purpose of the survey was not to try to evaluate the science of medical practice but to "look toward controlling prescribing costs in terms of generic vs proprietary drugs."[7] The survey was "coincidental with the 1962 Harris-Kefauver Amendment that for the first time mandated pre-marketing efficacy for medications. The survey was done in England, which has no law comparable to the U.S. Food, Drug, and Cosmetic Act.[7]

The question of how much of modern medical intervention is evidence-based is very difficult to answer. A study by Ellis et al[8] in 1995 showed that of 109 primary treatments administered to 109 patients, there was randomized clinical trial support for 53%, or unanimity by the general medical team about the existence of convincing nonexperimental evidence in 29%. Another study by Gill et al[9] showed that 31 of 101 interventions were based on random clinical trials and 51 of 101 were based on convincing nonexperimental evidence. While these 2 studies by themselves are insufficient to arrive at a conclusive answer to the question, they at least point towards the actual percentage as probably being much higher than stated by Dr White.

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The author responds:

It was with interest that I read the thoughtful letter by Wayne C Anderson RRT regarding my point of view article on the use of pulse oximetry.[1] He has performed for us a vital service in pointing out that all data are not created equal. Indeed, the Office of Technology Assessment's claim that only 10–20% of modern medical interventions has ever been tested is just an estimate. There are 2 reasons this rather feeble piece of data is so often cited. First, it is one of few citations that address the subject of the aggregate efficacy of interventions. Second, it fits so well with the observations of so many health services researchers.

The 10–20% estimate is weak indeed, but to call it a myth seems to be hyperbole. We learn with each passing year that some of our most deeply held assumptions about the utility of what we do are, after all, not true. I outlined some evidence of this in my oximetry paper. There are too many of these examples to list them all, but some that come readily to mind are intermittent positive pressure breathing, chest physiotherapy, antibiotics in otitis media, antibiotics in pharyngitis, and internal fetal heart rate monitoring.

Mr Anderson suggests that actually a much higher percentage of interventions have been shown to be "evidence-based." He cites several interesting publications in support of his position. In the paper by Ellis et al,[2] some 109 interventions were evaluated. The author claims that 58 of these were supported by evidence from randomized controlled trials and 32 from "convincing nonexperimental evidence," thus indicating that 82% of interventions were evidence-based.

I found this study to be deeply flawed. We have no idea how many interventions these patients received. All we know from the authors is what the "primary" intervention was. What were the nursing interventions? How were the patients monitored? What methods, other than the primary interventions, were utilized? What laboratory work was drawn? What other diagnostic interventions were these patients subjected to? What respiratory therapy, physical therapy, dietary, occupational therapy, or rehabilitative procedures were utilized?

I found that of the 90 interventions found to be "evidence-based," 82 were pharmaceuticals, which are probably the best studied of all types of interventions. Also, in 56 of the 58 cases noted by the authors to have been supported by randomized controlled trials, only one reference is cited. If we consider an intervention such as chest physiotherapy, there are numerous randomized trials published on both sides of the efficacy question. It seems to me that one published trial is somewhat thin "evidence."

The concept of "convincing nonexperimental evidence" is a very interesting idea. As a researcher, my initial reaction to this phrase was a midwestern colloquialism that I learned growing up, "there ain't no such animal." However, after a bit of reflection and further reading, my view somewhat modified. Clearly, there are some interventions that need not be subjected to controlled trials and for which there are compelling evidence. Examples could include a revision of a malfunctioning ventricular-peritoneal shunt, or the insertion of a urinary catheter for relief of complete urinary tract obstruction. However, some of their "nonexperimental" evidence involved other less clearly proven practices, such as the untested use of antibiotics.

Another fundamental flaw of this type of study (and the other similar study cited by Mr Anderson[3]), was that the assessment of the quality of the evidence in support of the interventions used was made by the same community of physicians who initially ordered these interventions. There is potentially a serious conflict of interest at work here. I would not suggest that the physicians would intentionally misrepresent the evidence. I am, however, suggesting that you are asking them to do a very difficult thing, which is to admit that their "scientific" practice of medicine is often not based on very much "science." Of course, in the absence of evidence, physicians must indeed practice based on their best combination of reasoning, intuition, and judgement.

Remember that I did not suggest that only 10–20% of modern medical interventions "work" (eg, are evidence-based). I instead suggested that very few of these interventions have ever been tested.

I agree with Mr Anderson when he suggests that the number of modern medical interventions that will turn out (when tested) to be efficacious is probably higher than 10–20%. Unfortunately, we seem to have no idea how much higher. I hope it is much higher. I fear it is not.

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Diffusing Capacity and the Vasodilatory Response to INO

I always enjoy reading scientific conference issues of RESPIRATORY CARE, and find the post-script discussions among the panelists particularly stimulating to my propensity to ask questions, which I would like to do now through the Journal.

In the conference on inhaled nitric oxide (INO) Channick and Yung described the use of INO to challenge patients with pulmonary hypertension to determine vasoreactivity from changes in pulmonary artery pressure, which may help to predict responsiveness to vasodilator therapy.[1] My question to the authors is whether they have considered or are they aware of any research directed at using diffusion capacity of the lung for carbon monoxide (D_{LCO}) to gauge the vasodilatory response to INO? Since D_{LCO} in large part reflects pulmonary capillary blood volume,[2] an increase in D_{LCO} in response to INO might signify relaxation of the pulmonary vascular bed. If such a "D_{LCO}–INO" test were available and deemed sufficiently sensitive and specific, it might obviate the cost and risks associated with pulmonary artery catheterization in this setting.

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The authors respond:

We thank Mr Haynes for his thoughtful comments. Although one might expect D_{LCO} to be a surrogate marker of pulmonary blood flow in primary pulmonary hypertension, where changes in D_{LCO} would presumably reflect limitations in pulmonary circulation, it has been shown that D_{LCO} does not correlate with the severity of pulmonary hypertension. Patients with severe pulmonary hypertension may have normal D_{LCO}, and improvement in hemodynamics after treatment may not result in a corresponding increase in D_{LCO}.[1] In addition, data from our patients with primary pulmonary hypertension did not show any correlation between baseline D_{LCO} and various hemodynamic parameters, including pulmonary vasoreactivity (unpublished data). Our results are consistent with those reported by the National Institutes of Health Registry.[2,3] This discrepancy may reflect the variable role of other factors in pulmonary hypertension, such as pulmonary membrane diffusing capacity and ventilation/perfusion mismatch.

It may be interesting to see if changes in D_{LCO} correlate with vasoreactivity, although there would be some technical difficulties in measuring D_{LCO} during administration of INO. Other vasodilators, such as prostacyclin and calcium channel blockers, have significant systemic side effects, and acute vasodilator testing with these agents is best performed with close hemodynamic monitoring (ie, during right heart catheterization). Finally, right heart catheterization in patients with pulmonary hypertension provides additional information important in the management of these patients, such as cardiac output, right atrial pressure, and mixed venous oxygen content. Routine evaluation of primary pulmonary hypertension should therefore include a right heart catheterization, with testing for acute vasodilator response at the same time.

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Respiratory Care Anatomy and Physiology: Foundations for Clinical Practice. Will Beachey MED RRT. St Louis: Mosby; 1998. 409 pages. $40.

This text describes the anatomy and physiology of the body systems of primary interest to respiratory therapists: respiratory, cardiovascular, and renal. The section on respiratory anatomy and physiology is the most in depth, as would be expected. A section on physiologic issues related to aging and exercise is also included. Each chapter lists objectives and contains concept questions and clinical focus boxes to engage the reader with important points.

The primary intended audience is the student of cardiopulmonary care. The author states in the preface that clinicians such as respiratory therapists, physical therapists, nurses, and physician assistants who care for patients with cardiopulmonary disease will benefit from reading the book. This is a bold assertion for the author of an anatomy and physiology text.

The content of the text is well organized and detailed at an appropriate level. The book takes a fresh approach to anatomy and physiology; all important topics related to cardiopulmonary anatomy and physiology are presented. Each chapter is well illustrated with color figures that make study of the information enjoyable. A major feature of the book is the use of clinical focus boxes, of which there are approximately 100, each presenting a brief clinical scenario and discussion that illustrates how the information discussed in the chapter is important to patient care. Writing such clinical scenarios for students can be a real challenge, as students often have minimal background in patient care at the time they are studying anatomy and physiology. The author does an excellent job, however, of presenting scenarios that are presented in a manner basic enough for students but also applicable for clinicians. Students and clinicians who study these clinical focus boxes will gain wisdom that later will pay dividends in patient care.

The text is concisely written and easy to read. Objectives are stated at the beginning of each chapter in a manner that promotes learning at higher cognitive levels. The use of color in the headings of tables and chapter sections makes the book appealing to the eye. The concept questions found in each chapter are well thought out and stimulate the reader to ponder important principles (the answers to the questions are provided at the back of the book). The end of each chapter lists current references. The index is detailed and helpful in locating information.

I found no significant typographic errors or inaccurate statements in the text, although, as with any new book, there are a few minor problems. The terms "mucus" and "mucous" are inconsistently used at times (see Page 17). The answers to concept questions 2–5 and 2–6 are switched. And a discussion of the clinical signs and symptoms of respiratory acidosis appears to be missing from Chapter 13, since such a discussion *is* presented for respiratory alkalosis. However, these problems are not serious and in no way detract from the author's meeting the goals of the text.

The study of anatomy and physiology can be a mundane task that students trudge through on their way to the interesting information of clinical medicine. **Respiratory Care Anatomy and Physiology** is very helpful in bridging the gap between background information and clinically applicable knowledge. The text makes learning cardiopulmonary anatomy and physiology much more enjoyable and purposeful. Readers are getting a real bargain purchasing this well-written text with color figures for only $40. I have found it a very useful addition to my personal library, and recommend it to you as a student or clinician.

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Conquering Asthma: An Illustrated Guide to Understanding and Care for Adults, 2nd ed. Michael T Newhouse MD and Peter J Barnes DM. Hamilton, Ontario: Empowering Press, 1998. Softcover, illustrated, 107 pages. $14.95.

The second edition of **Conquering Asthma**, like its predecessor, is intended for the asthmatic patient. The publisher, Empowering Press, is aptly chosen, as the aim of this book is to inform and empower asthmatic patients so that they can "understand their disease so well that they can monitor it on a daily basis, determine when they are getting worse, and correct any deterioration long before it becomes severe." The authors attempt to accomplish this ambitious goal with a well organized and very readable text. It begins with a brief and very basic chapter on normal lung function and how this is altered in asthma, followed by chapters covering topics such as diagnosis of and conditions that can mimic asthma, asthma triggers, various treatments and how they work, control of symptoms, treatment of attacks, occupational asthma, asthma in pregnancy, effect of diet on asthma, and treatment at specialty centers.

The authors have done an excellent job and have created an outstanding resource, not only for asthmatic patients and their families, but also for nurses, respiratory therapists, and physicians. Caregivers will find this book useful, not as a reference or patient care guide, but for enhancing their interaction with their asthmatic patients. The chapters are well organized and flow logically one to the next. Explanations of concepts are appropriately free of "medicalese," which results in a more understandable, less intimidating text for the lay reader. All recommendations for treatment are sound, as would be expected from 2 such esteemed authors in this field. I was particularly impressed with the continued emphasis on control and prevention of symptoms and the emphasis on anti-inflammatory therapies, particularly inhaled corticosteroids, as the key to successful asthma therapy.

The writing style is clear, concise, and at times quite engaging. It reads more like a self-help manual than the standard medical education literature, which is indeed a plus for readers. However, it may be a bit sophisticated for some patients. I practice primarily in an urban county hospital, where the vast majority of patients are economically disadvantaged and have had limited educational opportunities, and it would be a daunting or even impossible book for many of them to undertake. However, for the majority of motivated patients with a reasonable degree of sophistication, this is an excellent resource.

The appearance of the book is, save for the cover, quite plain. All the illustrations are done in gray-scale, which makes them less than eye-catching and at times confusing, especially when different aspects of a figure are referred to by color in the legend (eg, Fig. 8–1, pg. 55). I don't feel, however, that this detracts from the effectiveness of the text. The index is adequate and is preceded by a very useful set of appendixes containing lists of such things as foods that contain tartrazine or sulfites, medications containing salicylates, and strategies to avoid environmental asthma triggers. All in all, this is a wonderful resource for patients who wish to take a proactive role in their asthma management.

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Conquering Childhood Asthma: An Illustrated Guide to the Understanding and Control of Childhood Asthma. Bruce K Rubin MD, Michael T Newhouse MD, and Peter J Barnes DM. Hamilton, Ontario: Empowering Press, 1998. Softcover, illustrated, 114 pages. $14.95

The need is great for good written materials and other media that address the many important aspects of care for children with asthma, given the seemingly paradoxical coexistence of commonly disappointing outcomes and powerful pharmacotherapy and treatment strategies. **Conquering Childhood Asthma** serves as a useful reference for those wishing to gain a greater understanding than can be obtained in most patient education programs.

Conquering Childhood Asthma is written primarily for parents of asthmatic children, but also provides useful information for other family members, asthmatic teenagers, and even some health care professionals interested in practical information about this common illness. The 14 major chapters offer a great deal of detail on all aspects of asthma, including normal physiology, the pathophysiology of asthma, diagnosis of asthma, medications, avoidable allergic and nonallergic triggers, treatment strategies, and common myths about asthma. The material is well organized, informative to those with a high interest level, illustrated in an interesting way, and indexed for quick reference.

This book's greatest strength is its thorough treatment of these many topics, but this feature is also its greatest weakness since it detracts from readability, particularly for those with a less keen yearning to understand as much as the book provides. At just over 100 pages, **Conquering Childhood Asthma** is not an easy read for most adults, but it is a good reference that should fill in the inevitable information gaps that develop after professional visits. A few topics in the book seem to stray beyond the likely interest level of even committed parents, such as treatment of anaphylaxis, steroid sparing agents, and illustrations of airway casts with progressive remodeling.

Important is the authors' willingness to increase expectations parents should have for their asthmatic children. The book does so in many places by making it clear when parents might be concerned that their children do or don't have asthma, what good health care should provide, how families can know they have a capable physician, and why they should be concerned about disappointing outcomes. The publisher's name, Empowering Press, is apt in that this book supports the growing need for patients and their families to understand the illness at a sufficient depth to be better health care consumers.

The authors represent the United States, Canada, and the United Kingdom, and, as a result, bring interesting perspectives that might not be familiar to some readers in different parts of the world. For example, many readers in the United States may not be familiar with "astringent rubs" and the problems these might bring. The severity levels described don't entirely match those recommended to physicians in some parts of the English-speaking world, but all are appropriate and useful.

Conquering Childhood Asthma provides an important comprehensive resource for the motivated and reasonably well educated parent or family member of asthmatic children. The authors should be commended for providing not only in-depth information, but also guidance and support that can assist parents in coaxing their health care system to provide what their children deserve.

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The Case Manager's Handbook, 2nd ed. Catherine M Mullahy RN. Gaithersburg, Maryland: Aspen Publishers, 1998. Hardcover, 592 pages. $51.00.

With the advent of managed care and the emphasis on efficient and effective health care, case management has become a strategy used by insurers, employers, and hospitals to reduce the fragmentation of care and ensure that patients are getting the best, most affordable care possible. Patients at high risk for complex medical care and, thus, expense are those most often targeted for case management, including patients with asthma, chronic obstructive pulmonary disease, and those requiring long-term ventilation or other respiratory care interventions. This has opened the field of case management to respiratory therapists, and many respiratory therapists are finding employment as case managers in positions that have traditionally been open only to nurses and social workers. Industrious respiratory therapists who take on these roles will have to navigate the complex system of relationships between providers, payers, and patients, in addition to gaining knowledge of current standards of treatment and available resources for all types of complex cases.

The second edition of **The Case Managers Handbook** is one source of needed information. Ms Mullahy writes that "Effective case management requires a well designed case identification methodology, flexibility in management options, the ability to move a person quickly through a system, and prompt decisions and exceptions to benefit plan language when needed." The purpose of the book is to "define good case management, examine the case management process in its entirety, and present practical procedural information . . . , to review current business applications and discuss future possibilities for professional case managers." She suggests that this book can be used as a training guide for new case managers and as a resource tool for handling the business aspect of case management. In this edition the author has added "nuts and bolts" information on managed care, as well as sections on newer delivery philosophies such as disease and demand management. This book is *not* intended to cover specific disease management strategies or treatment, though many are discussed in case studies in the last section. This book is appropriate for health care professionals who are currently practicing or considering case management and need insight into negotiating with insurance companies and physicians, and guidance in daily business practices.

The book is divided into 5 parts. References and appendixes related to topic content are located at the end of each chapter, and an index, appendixes, and a glossary are located at the end of the book. These are excellent, and one of the strengths of this book as a resource. The author utilizes her personal experience as a case manager to elaborate on the concepts presented. The first section is devoted to the roles of a case manager and the need for a broad-based knowledge of the systems that influence the options and selection of care. The author includes a discussion of insurance and managed care plans, which helps the reader understand the financial motivations for case management, based on how the plans are structured.

The fifth chapter covers the legal and ethical responsibilities of case management, expanding on these concepts from the first edition. Included in the appendix is an example of a written agreement, a legal issues checklist, and the Case Managers Society of America statement regarding ethical case management. This chapter is extremely important to anyone considering case management, since case managers must often balance the needs of all involved without compromising care or ethical standards.

The second section has 4 chapters devoted to the process of case management. Communication techniques and strategies to use with physicians, patients, payers, and lawyers are highlighted. The author points out the challenges of working with individuals who may view the role of the case manager with some skepticism, and gives ideas on how to allay fears and win cooperation and trust. The author frequently uses sample dialogue to illustrate her points. I often found this confusing and disruptive to the continuity of information presented. It might have been more instructive to include a checklist or outline of key points to consider when dealing with the various types of individuals encountered, based on their investment in the patient's care.

The third section is devoted to the administration and financial responsibilities of the case manager. Material covered includes developing a good financial and quality assurance report, communicating with chief executive officers, and starting a case management business. The success of case management depends on the financial savings to employers and insurance companies, and the satisfaction of the patients and families involved. The author gives a quick view of the fundamental business skills needed to succeed as an independent contractor. The references and sample forms are good resources for those with little previous business background.

One of the most useful chapters is on the credentialing organizations, and includes the requirements for taking their exams. Certification as a case manager is important in establishing credibility with other health care providers and insurance decision-makers. This chapter will help the reader evaluate credentialing options, and provides addresses and telephone numbers to contact the credentialing organizations.

The last section reviews case management strategies for various types of patients, using case studies. The case management processes that have been discussed in the previous chapters are applied to various scenarios, followed by an analysis of how care decisions were made. Decisions on treatment, as well as psycho-social problems and financial considerations, are included, allowing the reader to see how the processes presented are put into action.

For the most part, the book is organized and easy to read. Some of the headings within the chapters needed subheadings to break out important points for emphasis and ease of use. In the third chapter, under the heading "Talking to Referral Sources," the author discusses getting a referral, negotiating fees, and reviewing a policy for limitations, and discusses types of plans the case manager might encounter (eg, workman's compensation, and group medical plans). Subheadings on each of these topics would help the reader recognize key points and access important information quickly.

There is very little literature available to assist a new case manager in getting started, but Catherine Mullahy has drawn from her years of experience to assemble a book that can aid in the day-to-day operations of case management. Most health care professionals, respiratory therapists included, have very little knowledge of the financial aspects of health care delivery or the complexities of the insurance industry. Those venturing into case management will need the information included in Mullahy's book. I appreciated the references at the end of each chapter and the materials included in the appendixes, as well as the index, which is comprehensive and easy to use. The book covers many important ideas briefly, and the resources listed will help the reader obtain more comprehensive information. The book is an excellent resource and can serve as a point of departure for new case managers as they tackle the problems associated with planning good, efficient care for complex cases.

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1999 OPEN FORUM

at the

45th *International Respiratory Congress*

The Annual Convention & Exhibition of the American Association for Respiratory Care

December 13-16, 1999 • Las Vegas, Nevada U.S.A.

The OPEN FORUM at the *International Respiratory Congress* is a unique opportunity for attendees to experience the results of scientific studies performed by their colleagues. Abstracts and posters of their work are presented in a symposium format that encourages discussions and interactions among investigators and observers. Indeed, some attendees refer to the OPEN FORUM as the most significant event at the *Congress.*

The RESPIRATORY CARE Journal is proud to publish the abstracts of the papers to be presented at this year's 13 OPEN FORUM SYMPOSIA in Las Vegas (see pages 1216 - 1291). The number of abstracts, about 250, is the largest number ever. According to Mari Jones, AARC Program Committee Chair, "the quality of the abstracts is by far the best we have ever seen. This demonstrates that respiratory care practitioners are at the forefront in documenting what's important for the patient, in particular, and the respiratory care community, in general." Mari adds that abstracts accepted were not only from the United States, but also from Japan, Turkey, People's Republic of China, England, Spain, and other countries. Journal Editor in Chief, Dr David Pierson, agrees with Mari Jones's assessment and adds that most of the abstracts should result in manuscripts submitted for publication in the Journal.

We encourage you to attend the *International Respiratory Congress* and to participate in the exchange when the abstracts and posters are presented. If you have been there before, we know you are coming back. If you have never experienced an OPEN FORUM SYMPOSIUM, we guarantee you a unique educational experience.

See you in Las Vegas!

Ventilators and Mechanical Ventilation: Part 1
Monday, December 13, 2:00-3:55 pm
(Room 231, 233, 235)

Oxygen & Delivery Devices; Oximetry; Humidification
Monday, December 13, 2:00-3:55 pm
(Room 237, 239, 241)

Ventilators and Mechanical Ventilation: Part 2
Tuesday, December 14, 10:30 am-12:25 pm
(Room 231, 233, 235)

Diagnostics
Tuesday, December 14, 10:30 am-12:25 pm
(Room 237, 239, 241)

Monitoring
Tuesday, December 14, 2:00-3:55 pm
(Room 231, 233, 235)

Neonatal/Pediatrics Respiratory Care
Tuesday, December 14, 2:00-3:55 pm
(Room 237, 239, 241)

Ventilators and Mechanical Ventilation: Part 3
Wednesday, December 15, 9:30-11:25 am
(Room 231, 233, 235)

Tracheostomies and Endotracheal Tubes; Artificial Airways; Suctioning
Wednesday, December 15, 9:30-11:25 am
(Room 237, 239, 241)

Management Issues; Patient-Driven Protocols
Wednesday, December 15, 2:00-3:55 pm
(Room 231, 233, 235)

Nitric Oxide Today
Wednesday, December 15, 2:45-4:40 pm
(Room 237, 239, 241)

Treating Asthma
Thursday, December 16, 8:30-10:25 am
(Room 231, 233, 235)

Looking Into RC Education
Thursday, December 16, 8:30-10:25 am
(Room 237, 239, 241)

Aerosols; Bronchodilators
Thursday, December 16, 1:00-2:55 pm
(Room 231, 233, 235)

PARTIAL LIQUID VENTILATION: HISTOLOGIC AND MORPHEMETRIC DIFFERENCES BETWEEN FRC AND LOW DOSE AMOUNTS WITH EXOGENOUS SURFACTANT. Patricia A. Meyers RRT, JM Manaligod MD, EM Bendel-Stenzel MD, DR Bing RRT, SC Simonton MD, MC Mammel MD. Infant Pulmonary Research Center, Children's Hospital-St. Paul, Minnesota and Dept. Of Pediatrics, University of Minnesota, Mpls, MN.

Introduction: Partial liquid ventilation (PLV) using FRC amounts of perflubron (LiquiVent®), exogenous surfactant (Survanta®; S) and high frequency ventilation (HFV) have each been reported to cause less barotrauma in lung injured animals and humans. Does low dose PLV provide the same amount of protection? We evaluated histology and morphometry in 32 newborn piglets with saline lavage induced lung injury. Method: 32 newborn piglets were sedated, paralyzed, and ventilated using a volume target of 12cc/kg. We induced lung injury, defined as PaO2<60 torr at FiO2 1.0 and lung compliance reduction by >30%. After stabilization on conventional ventilation (CV, Dräger Babylog®), we randomized animals to 4 groups of 8 each: CV+S+PLV to FRC(28.5±5.7 mL/kg), HFV (SensorMedics 3100)+S, HFV+S+low PLV (10 mL/kg) and HFV+S+PLV to FRC(27.5±6.8mL/kg) and ventilated for 20 hrs. PLV animals had perfluorocarbon instilled intratracheally. Evaporative loss were replaced hourly by assessing meniscus in ET tube, HFV+S+low PLV received 3ml/kg/hr replacement. Ventilators were adjusted as in clinical use. Lungs were excised en block, inflated to 30 cm H2O pressure and fixed in 10% formalin. We scored alveolar and interstitial inflammation and hemorrhage, edema, atelectasis, necrosis, and presence of hyaline membranes on a 0=none to 4=100% involvement scale, for right and left upper and lower lobes. Upper and lower lobes were scored separately, then summed. Scores were analyzed using the Kruskal-Wallis test. We assessed group differences with the Newman-Keuls test.

Table 1: Histology, mean and total injury scores, upper (u) and lower (l) lobes

	Mean (u)	total (u)	mean (l)	total (l)
CV+S+PLV	0.45	3.63	0.36	2.88
HFV+S	0.88*	7.00*	0.95*	7.63*
HFV+S+lo PLV	0.40	3.19	0.32	2.56
HFV+S+PLV	0.36	2.88	0.30	2.38

Table 2; Morphometry, mean %tissue area and squared root of variance

	% area (u)	var. (u)	% area (l)	var. (l)
CV+S+PLV	33.96	10.66	29.21	9.06
HFV+S	49.11*	16.39†	58.05*	15.23*
HFV+S+lo PLV	28.79	13.00	30.70	11.11
HFV+S+PLV	27.23	9.85	31.72	10.31

* HFV+S is different from CV+S+PLV, HFV+S+lo PLV, and HFV+S+PLV(p<.022),
†HFV+S is different from CV+S+PLV, and HFV+S+lo PLV (p=.024)

Conclusion: Lung injury was similar in the PFC treated groups. HFV+S+low PLV resulted in similar injury, as the groups which received FRC amounts PFC. HFV+S resulted in more injury when compared to the PFC treated groups.

OF-99-018

PARTIAL LIQUID VENTILATION: PHYSIOLOGIC DIFFERENCES BETWEEN FRC AND LOW DOSE AMOUNTS WITH EXOGENOUS SURFACTANT. Patricia A. Meyers RRT, JM Manaligod MD, EM Bendel-Stenzel MD, DR Bing RRT, SC Simonton MD, MC Mammel MD. Infant Pulmonary Research Center, Children's Hospital-St. Paul, Minnesota and Dept. Of Pediatrics, University of Minnesota, Minneapolis, MN.

Introduction: Does low dose partial liquid ventilation (PLV) with perflubron (LiquiVent®) and surfactant (Survanta®; S) provide the same level of improvement in lung injured animals as FRC dose with S. We evaluated physiologic responses in 32 surfactant depleted newborn piglets. Method: 32 newborn piglets were sedated, paralyzed, and ventilated using a volume target of 12cc/kg. We induced lung injury, defined as PaO2<60 torr at FiO2 1.0 and lung compliance reduction by > 30%, with repeated saline lavage. After stabilization on CV (Dräger Babylog®), we randomized animals to 4 groups of 8 each: conventional ventilation (CV)+S+PLV to FRC(28.5±5.7 mL/kg), high frequency ventilation (HFV; SensorMedics 3100)+S, HFV+S+low PLV (10 mL/kg) and HFV+S+PLV to FRC(27.5±6.8mL/kg) and ventilated for 20 hrs. PLV animals had perfluorocarbon instilled intratracheally. Evaporative loss were replaced hourly by assessing meniscus in ET tube, HFV+S+low PLV received 3ml/kg/hr replacement. We measured arterial blood gases, arterial and central venous pressures, heart rates, and calculated A/a ratio and OI every hour. Ventilators were adjusted as in clinical use. All techniques provided similar physiologic stability. HFV required higher Paw than CV.

		3hr	**8hr**	**12hr**	**16hr**	**20hr**
CV+S+PLV	**Paw**	14*	13*	13*	12*	12**
	pH	7.36	7.37	7.34	7.36	7.35
	a/A	0.39	0.42	0.39	0.46	0.44
HFV+S	**Paw**	18	15	15	14†	16
	pH	7.36	7.36	7.33	7.34	7.34
	a/A	0.41	0.45	.48	0.42	0.43
HFV+S+lowPLV	**Paw**	18	15	15	17	17
	pH	7.36	7.36	7.34	7.34	7.38
	a/A	0.46	0.44	.52	0.47	0.44
HFV+S+PLV	**Paw**	19	17	16	16	15
	pH	7.36	7.39	7.34	7.4	7.37
	a/A	0.41	0.46	.40	0.47	0.46

*p<0.05 CMV+S+PLV vs all; **p<0.05 CMV+S+PLV vs HFV+S+low PLV
†p<0.05 HFV+S vs HFV+S+low PLV

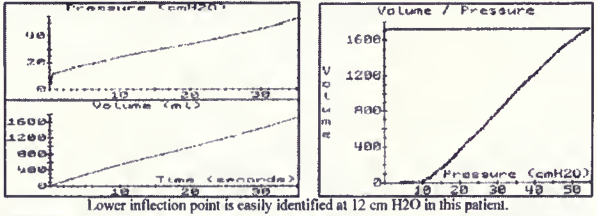
Conclusions: Gas exchange and cardiovascular stability was not enhanced by the combination of HFV+PLV. HFV+S+low PLV was not different from other PLV groups.

OF-99-029

LOW INSPIRATORY FLOW PRESSURE-VOLUME CURVES (PVC) FOR INFLECTION POINT DETERMINATION USING THE NOVAMETRIX VENTRAK MONITOR (NVT). Mark Siobal RRT, James Alonso RRT, Rich Kallet RRT, Roger Kraemer CRTT, James Marks MD. Respiratory Care Services, San Francisco General Hospital, UCSF Dept. of Anesthesia.

Introduction: Adjusting PEEP above the lower inflection point and limiting plateau pressure below the upper inflection point of the PVC is considered to be a key element in preventing re-expansion and over distension lung injury during ARDS and ALI. Incremental volume inflation and static pressure measurements using a super syringe is time consuming, labor intensive, and subject to technique variability. PVC determination using the super syringe technique has been shown to correlate closely when compared to the low flow inflation method [1,2]. We describe a simple method to record a low inspiratory flow PVC for inflection point determination using the Novametrix VenTrak Respiratory Mechanics Workstation.

Method: The NVT with attached printer, a Pediatric/Adult flow sensor, an oxygen gas source connected to a Washington T adapter (WT) are the supplies needed. Following connection of the NVT to the sedated patient and a brief period of ventilation with 100% oxygen, the patient is disconnected from the ventilator and attached to a WT with an oxygen flow set at 3 liters per minute. After 10 seconds of apnea, the open end of the WT is occluded for 30 seconds and a slow inflation to a volume of 1.5 liters is achieved. The patient is allowed to passively exhale and is reattached to the ventilator. The monitoring session is terminated and saved. The review recordings function is used to view the P-V curve in the combination waveform screen format and printed using the print screen command. The hard copy of the P-V curve can then be viewed and analyzed visually for lower and upper inflection point determination.



Lower inflection point is easily identified at 12 cm H2O in this patient.

Conclusion: This simplified method brings PVC measurement to the bedside utilizing a relatively inexpensive, commercially available device. Our experience in using this technique in critically ill patients has proven it to be safe and easily performed within a two minute time span. It requires little training or practice to master and facilitates the interpretation of the results. We believe this method provides another accurate alternative for performing this important clinical measurement.

1)Mankikian B, Lemaire F, Benito S, et al. A new device for measurement of pulmonary pressure-volume curves in patients on mechanical ventilation. Crit Care Med 1983;11:897-901.
2) Lu Q, Viera S , Richecoeur J, et al. A simple automated method for measuring pressure-volume curves during mechanical ventilation. Am J Crit Care Med 1999;159:275-282.

OF-99-035

TREATMENT OF BRONCHOPLEURAL FISTULA DUE TO ANAPLASTIC T-CELL LYMPHOMA USING INDEPENDENT LUNG VENTILATION-CASE PRESENTATION

De'Ann Laufenberg RRT, Maureen Madsen RRT, Ileana Cuervo RRT, Iftikhar Hanif MD, David Drucker MD, Gerald Lavandosky MD, Joe DiMaggio Children's Hospital, Hollywood, FL **Introduction:** Utilizing conventional mechanical ventilation to support patients with lung or airway injury creates the potential for additional pulmonary damage. Independent lung ventilation (ILV) has been advocated to limit further injury to the diseased lung segment and avoid barotrauma/volumtrauma to healthy segments. We describe a case of synchronized ILV in a pediatric patient with airway injury. **Case Summary:** A previously healthy seven year old male weighing twenty-eight kg presented to the emergency department in respiratory distress with wheezing and stridor. A chest radiograph revealed a mediastinal mass, and a biopsy was performed which revealed anaplastic T-cell lymphoma. While intubated and ventilated for tracheal compression, he underwent three days of radiation therapy to facilitate tumor shrinkage. A right-sided air leak developed secondary to a bronchopleural fistula, therefore he was re-intubated using a double lumen endotracheal tube (ETT) and the left lung was mechanically ventilated with low Vt while the right lung was placed on CPAP. Bronchoscopic evaluation of the airway revealed a 5 cm tracheal tear extending from the end of the trachea into the right mainstem and right upper lobe bronchus. Post-operatively, hypercarbia and hypoxemia developed. A fogarty catheter was placed into the right mainstem to prevent ventilation to the right lung, and a 5.5 cuffed ETT was placed into the trachea to ventilate the left lung. Ten days later, the left and right mainstems were selectively intubated with individual cuffed ETTs through a tracheostomy stoma. ILV was instituted using two Siemens Servo 300 ventilators in the pressure regulated volume control mode. Both lungs received a rate of 24, Peep of 5 cm H_2O, FiO_2 of 0.45. The exhaled Vt was 270 mls for the left lung and 70 mls for the right lung. He remained stable, sedated, and paralyzed on ILV for four weeks before undergoing a right upper and middle lobectomy with repair of his tracheal defect. He returned from the operating room nasally intubated, and was extubated in five days. This patient spent sixty-eight days in the PICU, and sixty of those days on a ventilator. Three weeks after being transferred to the floor, he was discharged home to receive outpatient chemotherapy. **Discussion:** We believe the patient benefited from ILV in several ways: 1) it allowed the injured airway to be bypassed until repair could be accomplished, 2) safe ventilation was delivered to the healthy lung, and 3) more invasive support (i.e. ECMO) was avoided.

OF-99-038

OUTCOMES OF NEW VENTILATOR TECHNOLOGIES ON PATIENTS IN AN ICU by Steven R. Mitchem, RRT and Joe Dwan, MS, RRT, Kaiser Sunnyside Medical Center, Clackamas, OR. This retrospective study compares ventilator length of stay (VLOS) over a three year period, Jan.96-Dec 98. New generation technology ventilators, Siemens Servo 300's, with graphics & PetCO2 monitors were purchased Dec. 1995. Did new modes, graphics & PetCO2 monitor change VLOS? VLOS data was obtained by counting ventilator hours by patient & disease documented by therapists on the patient's billing cardex. The data for specific dx were reviewed before and after implementing the new technologies. We believe that technology differences relating to VLOS would be more evident within the more complex disease DRG categories. VLOS per day was calculated by disease category monthly. We showed a reduction in VLOS over 3 years.

VLOS	1996	1997	1998
ARDS	16.96(n=9)	10.88(n=9)	3.86(n=11)
COPD	3.64(n=14)	10.57(n=14)	2.04(n=26)
CHF/CARDIAC	3.29(n=21)	1.65(n=12)	1.65(n=33)
ARF	4.00(n=45)	2.94(n=33)	2.07(n=46)

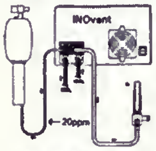
Did the many ICU variables determine our VLOS outcomes? The RCP & ICU physician staff remained stable throughout the trail, with 1 turnover each. Nursing staff changed, but protocols (including sedation) remained consistent. Low volume, permissive hypercapnia protection strategy was implemented in 1995. The ventilator acquired pneumonia rates were consistently below national average. Patient acuity remained consistent in our 13 bed ICU. Standard modes changed from SIMV,PS, PC & A/C to PRVC, PC, VS, PS. After considering the above variables, we were left with the new technology hypothesis. We felt the new technologies and the comprehensive training programs undertaken, enabling the staff to best utilize them, represent the greatest improvement in our ventilator management. We therefore concluded that the improvement in outcomes must be primarily related to the application of new ventilator technologies. In conclusion, we freely admit the lack of scientific controls over the variables related to our data. However, we feel the validity of the study has merit. Our volume & facility is small and lacks resources for research. We look to the larger facilities to provide the research to answer these questions. In the end, we are encouraged by the fact that for whatever reasons our VLOS has decreased over this time period. We feel this must be the ultimate goal for any Respiratory Care Department. OF-99-043

MANUAL RESUSCITATION BAG PERFORMANCE WITH THE OHMEDA INOvent®

Don Renaghan RRT, Respiratory Care Services
UCSF Stanford Health Care Stanford, California

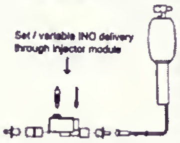
Background The utilization of the INOvent (Ohmeda Inc) for in-house transport of nitric oxide (NO) dependent adult petients is most efficient and compatible with a portable transport vantilator. In the absence of a suitable transport ventilator, the INOvent can provide manual delivery of inhaled nitric oxide (INO) at a fixed concentration of 20 ppm via a pneumatic delivery system, or at a variable concentration with the injector module in-line with a manual resuscitation bag. This in vitro study investigated the performance of three adult manual resuscitation bag designs and their performance with two manual inhaled nitric oxide delivery configurations from the INOvent. **Methods** Open reservoir (PMR 2), closed reservoir (AMBU), and Jackson-Rees design bags were configured with both manual and injector module configurations. Manual bagging was performed through an Dual Adult TTL test lung with PneuView monitoring software (Michigan Instruments) to provide reproducible data from 10 and 20 L/min bagging scenarios.

Results 1. *Fixed concentration of 20 ppm INO via pneumatic delivery system:*



With a maximum flow output from the INOvent manual outlet at 23 L/min, Jackson-Rees and closed reservoir (AMBU) bag performance delivered INO values within 1ppm at 10 and 20 L/min. Open reservoir (PMR 2) design showed a progressive inefficiency as minute ventilation increased.
At 10 L/min bagging: mean $Fi0_2$ = 0.90 and NO= 15ppm
At 20 L/min bagging: mean $Fi0_2$ = 0.85 and NO= 14ppm

2. *Variable INO concentration via injector delivery system:* With a 15 L/min maximum flow output from en 'e' cylinder Bourdon gauge, Jackson-Rees and closed reservoir (AMBU) bag performance provided delivered INO values (5,10,20) within 1ppm during 10L/min bagging. The 20 L/min bagging scenario caused a decreased FiO_2 (0.95) with the AMBU bag, while maintaining accurate INO levels. Jackson-Rees bag design failed secondary to inadequate flow. Open reservoir (PMR 2) design allowed significant FiO_2 (0.78) and INO deficits as previously described.



Conclusions Optimal transport utilization of the INOvent is uncomplicated with a transport ventilator. In-line injector module configuration with a manual resuscitation bag provides the next best alternative with O_2 delivered via a Thorpe tube flowmeter, instead of a restricted Bourdon guage flowmeter, to the NO injector. Closed reservoir bags provide the most consistant O_2/NO delivery with this technique. Jackson-Rees design bags deliver high FiO_2 and accurate INO levels but remain source flow dependent. Open reservoir manual resuscitation bags perform poorly when V_E delivery increases or source flow is inadequate.

OF-99-057

ACCURACY OF DEAD SPACE TO TIDAL VOLUME RATIO (VD/VT) MEASUREMENTS IN ARDS.

JA Alonso RRT, RH Kallet MS RRT, T Nuckton MD, B Daniel RRT, J.F. Pittet and M.A. Mathay MD, Departments of Anesthesia and CVRI. University of California, San Francisco at San Francisco General Hospital, San 1001 Potrero Ave. San Francisco, CA 94110.

Introduction: V_D/V_T defines the portion of V_T that does not participate in gas exchange and may parallel the degree of ventilation-to-perfusion mismatching. High degrees of ventilation to poorly perfused lung regions has been reported in ARDS. (1) Measurements of V_D/V_T are done by collecting expired gases with either a Douglas bag, or an indirect calorimeter. However, unless the ventilator circuit is modified, the portion of the V_T that is compressed in the circuit during inspiration (compression volume or V_C) will mix with the expired gases. V_C will dilute the fraction of expired CO2 (FECO2) and result in overestimation of the V_D/V_T. Error in V_D/V_T measurements can be corrected by a mathematical formula that adjusts for the effects of V_C. Our objective was to determine the degree of error caused by V_C on V_D/V_T measurements in patient with in ARDS.
Methods: Fifty-four patients who met the North American/European ARDS definition (2) were enrolled. The V_D/V_T measurements were done within 24 hours of meeting ARDS criteria. All patients were mechanically ventilated in either pressure control or volume control ventilation with V_T of 10 mL/Kg. Mean expired carbon dioxide fraction (FECO2) was measured from a stable five-minute collection period with a Deltatrac indirect calorimeter. Mean carbon dioxide tension (PECO2) was calculated by multiplying the FECO2 by the barometric pressure. Corrected PECO2 was accomplished by the formula: PECO2 x V_T (V_T/V_C). The V_D/V_T was calculated for both corrected and uncorrected V_D/V_T using the Enghoff modification of the Bohr equation as given by the formula: (PaCO2 - PECO2) ÷ PaCO2.
Results: There was a significant difference between corrected and uncorrected V_D/V_T measurements (P<0.001). V_C was 2.6 ± 0.08 mL/cm H2O. A moderate correlation was found between the degree of measurement error (V_D/V_T uncorrected - V_D/V_T corrected) and the fraction of V_C to V_T (r = 0.54, P<0.001)

Parameter	Uncorrected V_D/V_T	Corrected V_D/V_T	PIP (cmH2O)	PEEP (cmH2O)	V_T (mL)	V_C (mL)
Mean	0.61	0.56	39	8	644	84
±SD	0.10	0.10	9.6	2.7	109	26

Conclusion: The average error for V_D/V_T measurements in patients with ARDS was app 5%. The use of low-compliant ventilator systems minimizes the influence V_C has on V_D/V_T measurements.

(1) Ralph DD, Robertson, et al. Distribution of ventilation and perfusion during positive end-expiratory pressure in the adult respiratory distress syndrome. Am Rev Respir Dis. 1985;131:54-60.
(2) Bernard GR, Artigas A, et al. 1994. The American-European consensus conference on ARDS. Am J Respir Crit Care Med.149 (3 Pt 1): 818-824.

OF-99-065

EMERGENCY DEPARTMENT VENTILATION WITHOUT INTUBATION FOR TREATMENT OF ACUTE PULMONARY EDEMA

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Objective: To assess acute cardiogenic pulmonary edema (ACPE) patient response to ventilatory support provided by non-invasive positive pressure ventilation (NPPV). Methods: During 1998, a convenience sample of adult patients presenting to the emergency department (ED) with ACPE were entered in the study. All patients received routine therapy consisting of oxygen, nitrates and diuretics. Study patients were started on full mask NPPV using a Mallinckrodt Inc. 7200® ventilator with settings of 10 cm H_2O pressure support, 5 cm H_2O PEEP and FiO_2 100%. Pressure support was titrated to achieve a tidal volume of 5-7 mL/kg, and PEEP titrated to achieve an oxygen saturation (SpO_2) > 90%. Outcome measures included endotracheal intubation (ETI), SpO_2, arterial blood gases (ABG), Borg dyspnea score and vital signs. Results: Eighteen patients with mean age 76.6 ± 14.7 years were entered in the study. Initial mean values on FiO_2 100% by non-rebreather mask: SpO_2 89 ± 11%, pH 7.17 ± .13, PaO_2 74 ± 27 mm Hg, $PaCO_2$ 60 ± 19 mm Hg, Borg score 7.9 ± 1.4, and respiratory rate (RR) 38 ± 7. At 60 minutes following initiation of NPPV the mean values showed: SpO_2 98 ± 2%, pH 7.28 ± .09 (p= .007), PaO_2 187 ± 122 mm Hg, $PaCO_2$ 45 ± 16 mm Hg, Borg score 3.8 ± 2.3 (p= .002), and RR 29 ± 9 (p= .004). NPPV duration ranged from 30 minutes to 36 hours (median 3 hours). There were no problems with patient tolerance of NPPV. Sixteen patients (89%) improved allowing cessation of NPPV. Two patients required ETI (both had concomitant severe COPD). There were no complications of NPPV. Conclusion: Ventilatory support without ETI using a full face mask and conventional volume ventilator is an effective treatment for ACPE. Use of NPPV in the emergency department setting is feasible and may help prevent ETI.

OF-99-068

Pressure Rise Time (PRT) Increases Work of Breathing (WOB) during Pressure Support Ventilation (PsV)

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Introduction: PSV may lessen WOB by its initial high peak inspiratory flow ($\dot{V}I$). PRT regulates the rate-rise in airway pressure (P_{AW}) by limiting the acceleration of $\dot{V}I$ to its peak. As the timing of peak $\dot{V}I$ is delayed to a later point in inspiratory time (T_I), peak $\dot{V}I$ decreases because lung volume (and pressure) is higher. Because spontaneous peak $\dot{V}I$ occurs by 20% of inspiration (1), we hypothesized that increasing PRT will increase WOB.

Methods: A Hamilton Veolar set in volume ventilation with a modified sine wave, a rate = 26 and a $T_I/T_{TOT} = 0.40$ powered a work of breathing lung model (2). A V_T of 300 and 600 mL created two levels of simulated drive. A Drager E-2 was set at PS levels of 10 and 30 cmH2O above 5 cmH2O of PEEP. PRT was set at 0, 0.2 0.4 and 0.6 sec. Lung compliance was 35 mL/cmH2O and airway resistance was 8 cmH2O/L/sec. Measurements were made with a BICORE CP-100 monitor. WOB was expressed in Joules/L.

Results: As PS increased for any level of PRT, WOB decreased. The exception was for PRT = 0.6 at PS = 30, where T_I/T_{TOT} increased to 0.56 and resulted in air-trapping(‡). For any level of PS, WOB increased as PRT was increased. Clinically relevant differences in WOB with increased PRT only occurred at high VT demand and low PS. All differences in WOB were significant by paired t-tests using Dunn's multiple comparison test (p<.05)

WOB in Joules / L at:	PRT 0	PRT 0. 2	PRT 0.4	PRT 0.6
PS 10 (VT = 300)	0.04	0.08	0.08	0.13
PS 30	0.02	0.03	0.07	0.19‡
PS 10 (VT = 600)	0.12	0.24	0.33	0.42
PS 30	0.04	0.09	0.13	0.16

Conclusion: PRT increases WOB at low level PS and high V_T demand or when PRT markedly increases T_I/T_{TOT} beyond patient demand.

1.Silverman L, Lee G, et al: Air flow measurements on human subjects with and without respiratory resistance at several work rates. *Arch Indus Hyg & Occup Med* 1951; 3: 461-478

2. Katz JA, Kraemer RW, Gjerde GE: Inspiratory work and airway pressure with continuous positive airway pressure delivery systems. *Chest* 1985; 88: 519-526.

OF-99-094

THE ROLE OF PRESSURE-RISE TIME (PRT) AND PRESSURE SUPPORT (PS) LEVEL ON INSPIRATORY TIME (T_I) AND DUTY CYCLE (T_I/T_{TOT}).

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Introduction: PRT regulates the rate-rise in PS to a pressure plateau (P_{PLAT}) by limiting the acceleration of inspiratory flow ($\dot{V}I$). PRT may increase T_I both by delaying and decreasing peak $\dot{V}I$, thereby lowering the $\dot{V}I$ level needed to terminate inspiration. Alterations in $T_I$and T_I/T_{TOT} also may represent a respiratory drive response to changes in $\dot{V}I$ resulting from manipulations in PRT.(1) We examined the effects of varying PS and PRT on T_I and T_I/T_{TOT} at two levels of simulated drive.

Methods: A Hamilton Veolar set in volume ventilation with a modified sine wave, a rate = 26 and a $T_I/T_{TOT} = 0.40$ powered a work of breathing lung model (2). A V_T of 300 and 600 mL created two levels of simulated drive. A Drager E-2 was set at PS levels of 10 and 30 cmH2O above 5 cmH2O of PEEP. PRT was set at 0, 0.2 0.4 and 0.6 sec. Lung compliance was 35 mL/cmH2O and airway resistance was 8 cmH2O/L/sec. T_I, time to peak $\dot{V}I$ during inspiration (T_{IPF}) and T_I/T_{TOT} were measured with a Novametrix Ventrak monitor utilizing Analysis Plus software.

Results: Low V_T Demand: At low PS, increasing PRT did not alter T_I (0.74 sec) or T_I/T_{TOT}(.32). At high PS, T_I increased to 1.05 sec and T_I/T_{TOT} increased to.46. Increasing PRT increased T_I further to 1.28 sec and increased T_I/T_{TOT} to .56. At low PS T_{IPF} remained at 0.2 sec when PRT increased. P_{PLAT} was achieved by lowering peak $\dot{V}I$ and altering flow contour to a sine wave. At high PS, T_{IPF} matched pre-set PRT and P_{PLAT}. High V_T Demand: At low PS, increasing PRT did not increase T_I (.82), T_I/T_{TOT} (.36) T_{IPF}.varied (.21-.35) but P_{PLAT} matched PRT. At high PS, T_I increased to 1.04; T_I/T_{TOT} increased to .45. Increasing PRT increased T_I further to 1.15 sec and T_I/T_{TOT} to 0.50. At high PS. T_{IPF} matched pre-set PRT and P_{PLAT}.

Conclusions: T_I and T_I/T_{TOT} increase independently of respiratory drive at high level PS and prolonged PRT. Low V_T demand coupled with high levels of PS and PRT cause the ventilator's timing to exceed simulated effort, which potentially may promote patient-ventilator dyssynchrony .

1. Brochard L: Pressure-support ventilation: Still a simple mode? *Intensive Care Med.* 1996; 22: 1137-1138.

2. Katz JA, Kraemer RW, Gjerde GE: Inspiratory work and airway pressure with continuous positive airway pressure delivery systems. *Chest* 1985; 88: 519-526.

OF-99-09B

TRANSPORT HIGH FREQUENCY VENTILATION USING THE VDR-3C PERCUSSIONATOR®.

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Background - The Children's Hospital of Orange County (CHOC) transport team frequently transports infants and children with respiratory and or cardiac failure for HFOV, Nitric Oxide, and/or ECMO. Increasingly patients are receiving high frequency ventilation (HFV) at the time of referral or have a diagnosis which might benefit from high frequency ventilation. This trend led us to search for a ventilator which could deliver HFV during transport. We report our implementation of transport HFV and our experience to date

The VDR®-3C Universal Logistical Percussionator® (Percussionaire® Corp., Sandpoint, Idaho) was developed by DR. F.M. Bird and delivers HFV and/or Tidal Ventilation via a fully pneumatic system. It is FDA approved for use in preterm infants through adults. It's reliability was displayed during Operation Desert Storm where it was used routinely for transport and perioperative ventilatory management. After consultation with Dr. Bird (D.V.), the VDR®-3C was chosen as our transport ventilator. A unique oxygen supply cart and manifold was developed by D.V. This increased the duration of time the ventilator could be used without changing gas source

Preparation - All transport personnel were inserviced on the features and indications for use of the VDR®-3C. Respiratory therapists received hands on in-hospital education and evaluation using the VDR®-3C prior to use during transport. A conventional transport ventilator has been brought on initial transports as a back-up should any deterioration with the VDR®-3C be seen Trancutaneous CO2 monitoring is used routinely to minimize the incidence of hypocarbia Continuous saturation monitoring is also employed.

Indications for use -The VDR®-3C is being used to transport any infant or child who is receiving HFV at the time that transport is requested. It is also used for infants who are failing conventional management, and those with diagnoses for which HFV is standard care such as air leak syndrome.

Experience to date - 7 transports have been performed using HFV. Cases have included: 2 term infants with sepsis/pneumonia. 1 term infant with MAS 2 preterm infants with air leak syndromes (pulmonary interstitial emphysema and broncho-pleural fistula) 1 term infant with pulmonary hemorrhage and 1 three year old with ARDS.

Duration of return transport has ranged from 30 to 130 minutes. During one transport HFV was combined with N.O. therapy. In all cases to date the oxygen saturation during transport was either improved (5/7) or unchanged (2/7) when compared with the 1 hour prior to transport. Arterial blood gasses obtained upon arrival at CHOC have shown CO2 to be within clinical target range (30 to 50 torr) in all patients. This is the first program to use VDR®-3C HFV during transport of children in the U.S.

OF-99-112

TECHNIQUES FOR ASSESSING SPONTANEOUS VENTILATORY PARAMETERS PRIOR TO WEANING: A SURVEY OF CURRENT PRACTICE AT UNIVERSITY HOSPITALS.

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Background: Spontaneous Ventilatory Parameters (SVPs) are an accepted part of the decision making process in discontinuing ventilation. The original validation literature used a consistent method for measuring SVPs. The patient is removed from the ventilator and minute ventilation (MV) measured with a cumulative meter. Frequency (f) is counted for that one minute period and the average tidal volume (Vt) calculated. No CPAP or pressure support (PS) is utilized. With the advent of mechanical ventilator digital measurement, some institutions now use the ventilator to collect SVPs. This method uses the breath-by-breath Vt and f displays to "approximate" the traditional parameters. MV is calculated from those estimates. This survey was conducted to determine what SVP methods are currently being utilized at university teaching hospitals and how this compares to the original validation literature. **Method:** We surveyed the 72 respiratory care departments of the University Health System Consortium using a written questionnaire with written and telephone follow-up. From November 1997 to January 1998, a twelve question survey was sent to each Department Head. The survey questions focused on demographics, weaning techniques, and SVP methodology. **Results:** Of the 72 surveys, 48 (67%) were returned and complete. Hospital sizes ranged from 110-1100 (mean 491) total beds with 11-120 (mean 59) ICU beds. Therapist Driven Protocols were used for at least some weaning in 69% (33/48) of the hospitals. The most commonly measured parameters were Vt (99%), f (96%), negative inspiratory force (NIF) (83%), vital capacity (VC) (81%), and MV (73%). Other measurements used less frequently were f/Vt ratio (27%), occlusion pressure (P100) (6%), and maximum voluntary ventilation (MVV) (2%). When measuring SVPs; 25% (12/48) of the hospitals always disconnect patients from the ventilator and measure using a meter, 44% (21/48) always use the ventilator display, 29% (14/48) use either method, and 2% (1/48) never monitor SVPs. Therefore, 73% (35/48) of the hospitals use the ventilator to measure SVPs at least some of the time. Of these, 46% (16/35) use some level of added CPAP and 20% (7/35) use some level of added PS. In hospitals in which SVPs are measured off the ventilator, they are done with the patient breathing room air in 96% (25/26) of institutions. Lastly, 85% (41/48) of the hospitals have no set period of time to wait before measuring SVPs. Of the 15% (7/48) that wait a set period of time, 5/7 wait one minute. **Discussion:** Both using SVPs to predict successful spontaneous ventilation and the process to collect that information have been well documented in the literature. This survey suggests that most hospitals currently use techniques that differ markedly from these established methods, at least for some patients. Vt measurement using the ventilator display may vary with each breath. This coupled with a f that is calculated on a rolling 12 second average (depending on the ventilator), may skew the calculated MV. In addition, the incorporation of CPAP and PS into SVP measurement has not been studied. Whether measurement variation and differences in the SVP process are clinically relevant is unknown, but both should be evaluated more fully. The specific parameters used continue to be consistent with earlier literature but only 27% of the hospitals utilize the f/Vt ratio, which has been found to be the most reliable index to predict weaning failure. Also, 96% of the group that measures SVPs off the ventilator do so on room air which could increase the number of desaturation complications.

OF-99-130

LAB EVALUATION OF THE PULMONETICS LTV 1000 VENTILATOR

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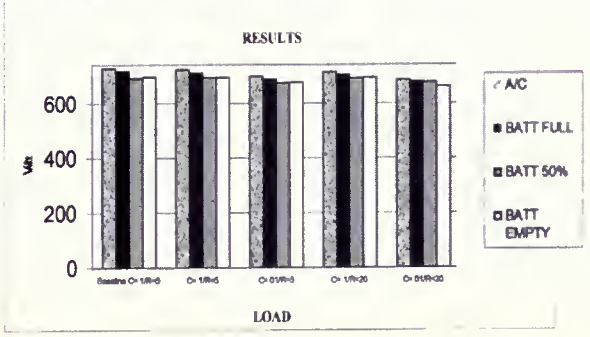
Background: Electronic and mechanical miniaturization has made it possible to compress what was once a large ICU ventilator into a laptop-sized, portable ventilator. With its internal battery and miniature blower. it is self-contained, except for an oxygen source necessary only to deliver FIO2 above .21. Our objective was to evaluate the LTV for accuracy of volume delivery under varied patient loads and power source conditions. The ventilator was tested under the following power source conditions: 1) A/C power, 2) battery fully charged, 3) battery 50% depleted, and 4) with the battery "empty," a warning that the battery is at its lowest charge level, with less than 10 min. of use left before a complete shutdown. A Vt change of less than 10% across all conditions was considered acceptable. **Methods:** The LTV was set to deliver a Vt of .700L to a test lung (TTL Michigan Instruments) under various combinations of compliance and airway resistance and powered under different conditions (see table). A VenTrack 1550 (Novametrix Inc.) was connected at the airway to measure delivered tidal volume and monitor airway pressure. Three sample readings were averaged for each of the test situations. The ventilator was allowed to stabilize for 60 sec. before readings were taken. **Results:** The largest average Vt .728L was under "Baseline conditions". The lowest average Vt .660L was under the highest test lung load with "Battery Empty" conditions. **Conclusion:** The difference in Vt due to changes in power supply conditions are between 3% and 5%. The difference in Vt due to changes in test lung load are between 3% and 6%. Some of this can be accounted for in the ventilator circuit compliance. A situation in which all of the worst conditions were to occur are not only highly unlikely, but still causes less than a 10% change. Under all conditions tested, there was a minimal effect on ventilator output. We find the effect to be clinically insignificant.



OF-99-133

NONINVASIVE POSITIVE PRESSURE VENTILATION DURING PERCUTANEOUS GASTROSTOMY PLACEMENT IN AMYOTROPHIC LATERAL SCLEROSIS

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Percutaneous endoscopic gastrostomy (PEG) tube placement can be a life prolonging intervention for patients with amyotrophic lateral sclerosis (ALS). A percutaneous gastrostomy tube can reduce the potential for aspiration, provide increased nutritional support and improve the patient's quality of life. Because of the perceived risk of precipitating acute respiratory failure during conscious sedation for this procedure, some have suggested that significant impairment of vital capacity is a contra-indication to PEG tube placement. We describe the use of noninvasive positive pressure ventilation (NPPV) for respiratory support during conscious sedation for a PEG procedure in two ALS patients, one having severe bulbar symptoms. Inspiratory pressure and timed breath rate were adjusted to support the patient while monitoring electrocardiogram, oxygen saturation, estimated tidal volume and respiratory rate during the PEG procedure. The primary risk of NPPV is the lack of a secure airway during respiratory support of the PEG procedure with sedation. This technique requires both a physician and a respiratory care practitioner familiar with NPPV, as well as a patient fully acclimated to the use of NPPV. The use of NPPV as respiratory support for the placement of a percutaneous gastrostomy tube can increase the period of opportunity to perform the procedure in chronic neuromuscular patients with severe respiratory insufficiency.

	Patient No. 1		Patient No. 2	
	Measured (liters)	Percent Predicted	Measured (liters)	Percent Predicted
FVC	1.31	26%	1.17	21%
FEV1	1.24	31%	.90	20%

OF-99-142

CLINICAL EVALUATION OF THE ACHIEVA VENTILATOR.

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INTRODUCTION: The Achieva ventilator (Mallinkrodt/NPB, Minneapolis) is a new subacute care vent that is piston-based and is equipped with pressure control, pressure support, and flow triggering. We evaluated the Achieva clinically in terms of gas exchange, ventilatory parameters, and patient comfort. **METHODS:** Ten stable, mechanically ventilated ICU pts were placed on the Achieva after obtaining informed consent. Settings were identical to those provided with a standard ICU ventilator. Pts were monitored continuously for 4 hrs and an ABG was drawn for comparison with values obtained while on the ICU ventilator. Ventilatory variables (f, V_T, V_E, PIP) were measured, recorded and compared between ventilators. Each pt was asked to rate "ease of breathing" (EOB) as: 1) very difficult, 2) difficult, 3) easy, or 4) very easy. **RESULTS:** Mean ventilator settings were SIMV rate of 3.8, V_T of 755, PEEP of 6.0, PSV of 13.1, T_i of 1.1, and F_iO_2 of 0.41. Table 1 shows the results (mean ± SD) for ABGs, ventilatory variables, and EOB for both ventilation periods.

Table 1.	Achieva	ICU Vent.
$PaCO_2$ (mmHg)	41.3 ± 9.7	39.9 ± 9.3
PaO_2 (mmHg)	98.6 ± 32.3	99.4 ± 19.6
PIP (cmH_2O)	34 ± 3.5	34 ± 5.2
Spont V_T (ml)	422 ± 71	417 ± 101
Spont f (bpm)	17 ± 5.5	18 ± 5.7
V_E (L/min)	10.5 ± 3.7	10.4 ± 3.1
EOB	3.1 ± 0.7	3.1 ± 0.9

Three pts experienced dyssnychrony with the Achieva during the trial. These periods were usually associated with a "volume alarm" and were generally resolved after suctioning of the airway. **CONCLUSION:** The Achieva provides ventilation, oxygenation, and ease of breathing comparable to standard ICU ventilators in this sample of stable ICU pts.

OF-99-147

LABORATORY EVALUATION OF FOUR PORTABLE VENTILATORS (PVTs).

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INTRODUCTION: Traditionally, PVTs have high imposed work of breathing (WOB_I). Newer PVTs include flow triggering and PSV to minimize WOB_I. We compared the WOB_I and response time (RT) of 4 PVTs on a lung model. **METHODS:** A two-chambered test lung (TTL) was modified to mimic spont breathing. An Evita 4 (Drager) powered the "drive" lung at 3 volume and flow conditions: 1) 300 ml @ 40 L/min, 2) 500 ml @ 60 L/min, and 3) 800 ml @ 80 L/min. TTL characteristics were C of 50 ml/cmH2O and R of 5 cmH2O/L/sec. PVTs (Achieva, T-Bird, 740, LTV) were attached to "pt" lung with flow trigger of 2 and set at PEEP/PSV combinations of: 0/0, 0/10, 5/0, and 5/10. Five breaths at each setting were analyzed and data recorded = WOB_I, peak negative pressure (PNP), RT and V_T. **RESULTS:** WOB_I was higher with Achieva with PEEP set. Table 1 shows results (mean ± SD) at 0/10 (cond #2). Table 2 shows results at 5/0 (cond # 2).

Table 1.	WOB_I (mJ/L)	PNP (cmH_2O)	RT (Sec)
Achieva	0.2 ± 0.02	-0.5 ± 0.03	0.12 ± 0.02
LTV 1000	0.9 ± 0.2	-0.9 ± 0.1	0.14 ± 0.02
T-Bird	0.06 ± 0.02	-0.1 ± 0.03	0.14 ± 0.02
740	1.0 ± 0.3	-1.24 ± 0.06	0.17 ± 0.02
Table 2.	WOB_I (mJ/L)	PNP (cmH_2O)	RT (Sec)
Achieva	67.0 ± 3.0	0.41 ± 0.2	0.5 ± 0.04
LTV 1000	18.0 ± 1.5	-0.1 ± 0.1	0.25 ± 0.02
T-Bird	13.0 ± 0.2	2.30 ± 0.03	0.27 ± 0.02
740	8.0 ± 1.3	3.6 ± 0.1	0.32 ± 0.02

CONCLUSION: WOB_I on these PVTs is clinically acceptable and may be minimized by adding PSV.

OF-99-148

LABORATORY AND CLINICAL EVALUATION OF THE LTV1000 PORTABLE VENTILATOR (PV).

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Background: PVs are designed for use during transport and subacute care. LTV 1000 (Pulmonetic Systems, Inc.) is a new PV that uses a internal flow generator. We evaluated the LTV 1000 in laboratory and clinical settings. **Methods:** Lab) Ability of LTV1000 to deliver and measure set tidal volume (V_T) during changing compliance (C) was evaluated. Gas consumption, batt duration, accuracy and response to changing F_IO_2, and alarm systems were assessed. A two-chamber lung model was used to evaluate triggering at different PEEP levels. Clin) Six pts requiring transport were ventilated with LTV 1000 at same settings as the ICU vent. Measured respiratory parameters and ABGs were compared between the LTV 1000 and ICU vent. **Results:** Lab) There were small decreases in V_T as C changed from 0.1 to 0.02 L/cmH_2O. Measured V_T was within 10% of actual V_T at all conditions. An E-tank was used until "low inlet pressure" alarm was activated (83" at F_IO_2 of 0.6) and (45" at F_IO_2 of 1.0). Measured F_IO_2 increased from 0.21 to 1.0 in 28 sec. Measured F_IO_2 was within 3% of setting across the control range. All alarms functioned according to manufacturer's specs. Triggering from PEEP of 0 and 5 cmH_2O resulted in peak negative pressure of -2.6 cmH_2O and -0.98 cm$H_2$0, respectively with demand flow of 40 L/min. Batt duration was 101" from full charge. "Batt Low" alarm occurred at 64" and "Batt Empty" alarm at 87". Clin) No significant changes in ABGs, PIP, P_{aw}, V_T, V_E, or pulse oximetry values were noted between LTV 1000 and ICU vent. Three pts were on PCV, four on PSV, and mean PEEP level was 8.2 cmH_2O. **Conclusions:** LTV 1000 is a versatile, reliable PV capable of maintaining gas exchange and respiratory mechanics comparable to current ICU ventilators.

OF-99-149

MANUAL VENTILATION (MV) DURING ANESTHESIA: EFFECTS OF BREATHING BAG (BB) SIZE AND SHAPE.

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Background: During anesthesia, MV is typically provided using a 3-L BB. Effective ventilation depends on fresh gas flow, clinician skill, pt impedance, and BB characteristics. We evaluated 3 types of BB during MV by 11 CRNA students. **Method:** An anesthesia ventilator and 40" coaxial circuit (F circuit, King Systems) was connected to a TTL with PneuView (Michigan Instruments). Volunteers (VOL) (6 men, 5 women) ventilated the TTL using 1) a standard 3-L BB, 2) a standard 2-L BB, and 3) a 2-L hourglass shaped (HS) BB. VOLs were instructed to ventilate the lung at V_T of 0.8 L and f of 12 b/min. PneuView measured airway pressures, V_T, V_E, peak flow, f, and inspiratory time. Lung C was set at 0.05 L/cmH_2O and R was set at 5 cmH_2O/L/s. Hand size was recorded. VOLs rated ease of use and perceived BB efficiency. Values were averaged over one minute. Results: Results are mean ± SD. ANOVA for repeated measures was used to compare variables using each BB.

BAG	Gender	2- L Std	3-L Std	2-L HS
V_T (L)	All	1.01 (0.11)	0.99 (0.11)	0.89 (0.08)*
	Men	1.06 (0.12)	1.03 (0.17)	0.94 (0.07)*
	Women	0.96 (0.11)	0.98 (0. 10)	0.87 (0.09)*
PIP (cmH_2O)	All	22.7 (3.0)	21.2 (2.5)	20.9 (2.3)
	Men	24.5 (3.7)	22.4 (4.2)	22.4 (1.4)
	Women	21.9 (3.4)	20.6 (1.5)	20.2 (2.4)

* $p < 0.05$ vs 2-L and 3-L standard bags

8 of 11 VOLs preferred the 2-L HS BB. 3 VOLs preferred the std 2-L BB. Ease of use and perceived control over ventilation was better with the 2-L BBs. **Conclusion:** V_T provided with 2-L HS BB was smaller and closer to the 0.8 L target compared to other BBs. Differences in V_T were statistically, but not clinically significant. The 2-L HS BB was preferred for ease of use compared to std 2-L and 3-L BBs.

OF-99-150

COMPARISON OF EXPIRATORY VALVE RESISTANCE OF THE MNPB 840 AND THE DRAGER E2 VENTILATORS DURING "FREE BREATHING" MODES AND INCREASING LEVELS OF CONTINUOUS POSITIVE AIRWAY PRESSURE

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Background: The MNPB 840 and Drager E2 ventilators incorporate open expiratory valve or "free breathing" systems. This allows a patient's spontaneous inspiratory and expiratory efforts to be superimposed upon pressure-regulated breaths. Minimizing dynamic gas trapping and imposed expiratory work requires a responsive, low resistance expiratory valve. We evaluated expiratory valve performance during "free breathingi"modes and with increasing levels of CPAP

Methods: A Hamilton Veolar set in volume ventilation with a modified sine wave, rate = 34, Vt =300 mL, and I:E = 1:2, simulated spontaneous breathing on a two compartment lung model. Compliance was set 30 mL/cm H2O with minimal airways resistance. Expiratory valve resistance was evaluated with determinations of: maximum expiratory pressure (MEP), peak expiratory flow (PEF), peak expiratory resistance (PER) and expiratory retard (ER). Pressure, flow, and time were measured from scalar waveforms with a Bicore CP-100 monitor. PER was calculated as MEP/PEF. ER was defined as the time from peak expiratory pressure to baseline pressure. Measurements were made on both ventilators during simulated spontaneous breathing on CPAP (0, 5, 10, and 20 cmH2O) and during MNPB 840 Pressure Controled SIMV (PC-SIMV), Drager E2 Airway Pressure Release Ventilation (APRV) and Pressure Controled Ventilation Plus (PCV+) modes. Peak inspiratory pressure was set at 20 with 5 cmH2O PEEP, rate = 6, and cycle ratio = 4:1 during PC-SIMV, APRV, and PCV+. Values from 4 breaths for MEP, PEF, PER and ER were averaged at each CPAP level and are reported as the pooled mean for each ventilator. Values from 3 - 4 superimposed spontaneous breaths at 20 cmH2O during PC-SIMV, APRV, and PCV+ were averaged.

Results: PER of the MNPB 840 remains constant during varying levels of CPAP but increases when the open expiratory valve "free breathing" feature is active. In contrast, PER across the Drager E2 expiratory valve decreases as the CPAP level is increased. PER was 12.4, 10.9, 10.1, and 8.4 cmH2O/L/sec at CPAP of 0, 5, 10, and 20 cmH2O respectively. PEF was highest during "free breathing" in both APRV and PCV+ when compared to all other test conditions.

	840 CPAP	E-2 CPAP	840 PC-SIMV	E-2 APRV and PCV+
MEP (cmH2O)	8.5	9.6	10	9
PEF (L/min)	52	55	50	59
PER (cmH2O/L/sec)	9.8	10.4	11.9	9.2
ER (sec)	0.58	0.46	1.1	0.46

Conclusion: Expiratory valve resistance differs between the two ventilators during "free breathing" modes and CPAP. At high respiratory rates this may affect dynamic gas trapping and expiratory work of breathing.

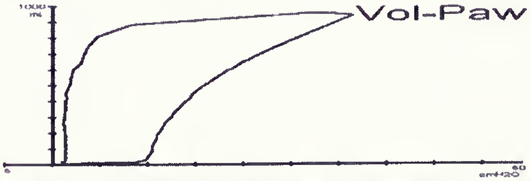
OF-99-152

INFLECTION POINT DETERMINATION USING THE DRAGER E2 VENTILATOR.

Mark Siobal RRT, James Alonso RRT, Rich Kallet RRT, Roger Kraemer CRTT, James Marks MD PhD. Respiratory Care Services, San Francisco General Hospital, Dept. of Anesthesia, UCSF

Introduction: Use of pressure-volume curves (PVC) to determine lower and upper inflection points for PEEP and plateau pressure adjustments are recognized to be key factors in preventing cyclic re-expansion and over distension lung injury. PVC determination using the super syringe technique correlates closely with low flow inflation methods (1,2). The super syringe method is time consuming, labor intensive, subject to technique variability, and requires that the patient be removed from the ventilator. The ideal method for this measurement should be easily performed using automated precision without removing the patient from the ventilator. We describe a PVC measurement method that partially meets these criteria using the Drager E2 ventilator.

Method: During ventilation in any mode on the E2, preset APRV mode parameters to mimic the current ventilation settings by adjusting cycle times and pressures. Switch the ventilator to the APRV mode and adjust the FiO2 to 100%. Following the switch to APRV, preset SIMV mode parameters to Vt = 990 ml, Insp. Time = 10 seconds, Rate = 0.5 per minute, Insp. Flow = 6L/min, PEEP = 0, Flow Trigger = 0, and Slope = 0. Sedate the patient until spontaneous respiratory efforts cease. Switch the mode to SIMV. After 10 seconds of apnea, press the manual inspiration button to deliver a slow inflation at the parameters set above. Allow the patient to passively exhale and immediately switch the mode back to APRV to resume ventilation. The PVC can then be viewed on the ventilator display if the freeze screen function is activated during the maneuver or printed from the Drager Evita View graphics extension application (see figure).



Conclusion: Our experience in using this technique in critically ill patients has proven to be safe when performed by properly trained personnel. It requires numerous manipulations of the ventilator and requires several practice runs on a test lung to achieve competency. Development of a fully automated algorithm is within the technological capabilities of current micro processor controlled ventilators. PVC determination using the Drager E2 ventilator appears to be a reasonable alternative method until an automated measurement maneuver becomes available.

1)Mankikian B, Lemaire F, Benito S, et al. A new device for measurement of pulmonary pressure-volume curves in patients on mechanical ventilation. Crit Care Med 1983;11:897-901.
2) Lu Q, Viera S , Richecoeur J, et al. A simple automated method for measuring pressure-volume curves during mechanical ventilation. Am J Crit Care Med 1999;159:275-282.

OF-99-153

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RISE TIME COMPARISON OF 4 DIFFERENT MECHANICAL VENTILATORS Corry Gelling RRT, Kelly Jager RRT, J.J. Ronco MD, Vancouver General Hospital, Vancouver, BC

Background: Rise time (RT), pressure slope or flow acceleration percent (FAP) is an adjunct designed to improve delivery of a pressure-targeted breath in mechanical ventilators. We compared the RT's of 4 different mechanical ventilators. **Method:** A 2-chambered test lung was used with a set compliance of 20 ml/cm H_2O and a normal resistance. Pressure signals at the "Y" of the test lung were digitized by a computer data-acquisition system. Two of each of the test ventilators (NPB 760, Bear 1000, NPB 840 and NPB 7200) was connected one at a time to the test lung. Each test ventilator was set in the assist control mode with a set pressure control level of 20 cm H_2O, an I:E ratio of 1:1 and 1:2.5, a respiratory rate of 12, room air and no PEEP. The sensitivity was set to 1 L/min in all ventilators except the 7200, set to 0.5 cm H_2O. A FAP setting of 5, 50 and 100 was used for the 760 and 840 ventilators. A pressure slope on the Bear 1000 was set to match the RT of the 840 ventilator when the I:E ratio was 1:1 and the FAP was 50% as a reference for comparison. The 7200 does not have an adjustable RT. **Results:** At a ratio of 1:1, a FAP of 5, 50 and 100% on the 840 and 760 corresponded to a pressure slope of -8, -6 and +8 respectively on the Bear 1000 ($p > 0.05$). An increase in the I:E ratio to 1:2.5 expectedly decreased the RT of the NPB ventilators. The RT of the 7200 was always significantly higher than the other ventilators ($p < .005$). The 760 and 840 RT's were similar to each other. There was always a very transient pressure overshoot in all ventilators when FAP or pressure slope was set at 100% or +8, respectively (exception was the 7200). The following example shows the mean RT's of 4 ventilators at an I:E ratio of 1:2.5 and an inspiratory time of 1.43 seconds.

Ventilator	FAP% or PS set	RT (seconds)
NPB 760	50	0.65
NPB 840	50	0.51
Bear 1000	-6	0.60
NPB 7200	NA	•1.43

• $p < 0.05$ when compared with other ventilators

Conclusions: It is useful to know how rise time settings relate to each other if a patient on pressure control or pressure support needs to be switched to another type of ventilator. Accounting for the differences in RT's, therefore will help improve consistency of a pressure-targeted breath.

OF-99-172

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A RETROSPECTIVE RANDOMIZED COMPARISON OF MECHANICAL VENTILATION WEANING PROTOCOL IN A TRAUMA INTENSIVE CARE UNIT. Stanley M. Baldwin, MBA, RRT, Frank Ercoli M.D., FACS., Sandi Aaronson RRT., Oscar J.Paz-Altschal M.D., FACS., Nikki Johnson RRT., Dennis Graham RRT., Department of Trauma Services and Pulmonary Services, Desert Regional Medical Center, Palm Springs, Ca..

Background: Previous studies have demonstrated the efficacy of weaning protocols when utilized in medical and surgical intensive care units. This study has examined a sample of ventilator dependent patients from a trauma population and proved the effectiveness of a weaning protocol when utilized by respiratory therapists working under physician guidance. Methods: " Trauma patients" were identified and selected from a sample of multiple injured patients admitted following accident to a designated trauma intensive care unit. The patients were randomized into two study groups, i.e.; protocol and non-protocol. Both groups were examined and chest x-rays compared for equality of associated co-morbidities as defined by the radiographic presence of infiltrates, contusions, atelectasis, hemothorax, pneumothorax, ARDS or other post traumatic sequelae. The main outcome measure was weaning time. Secondary outcomes were the need for re-intubation, duration of mechanical ventilation and total hospital costs related thereto. Results: 48 patients were randomized into two groups. Patient demographics including age, trauma score, associated co-morbidities and re-intubation rates were similar between the two groups.

Variable	1993 Physician Directed (n=24)	1997 Protocol Directed (n=24)	P-Value
Age, Yr.	36.7± 20.4	37.9± 20.2	
Male/ Female	13/11	14/10	
Trauma Score	13.3± 3.32	13.5± 3.42	
Co-Morbidity Chest, %	19/24 79%	19/24 79%	
Duration of MV, hrs.	132.2± 163.1	103.4± 159.1	0.186
Weaning Time, hrs.	19.3± 28.0	13.6± 26.8	0.345
Re-Intubation Rate	1/24	1/24	

Conclusions: Protocol guided weaning of mechanically ventilated patients by respiratory therapists in the trauma intensive care unit is safe. The protocol group led to an earlier and faster extubation rate than the group guided solely by physicians. A conservative per annum cost savings for the protocol group for hospital costs is $ 265,800/ yr.

OF-99-187

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RANDOMIZED, CONTROLLED, CLINICAL TRIAL OF AN INNOVATIVE SELF-HEATED HUMIDIFIER.

Shirley D. Broach, RRT, Charles G. Durbin, Jr., MD University of Virginia Health Systems, Charlottesville, Virginia 22908

INTRODUCTION: Inadequate humidity of inspired gases through an artificial airway adversely affects patient outcomes from retained secretions and damage to lung mucosa. The passive HME/HCH has replaced water-filled heated humidifiers in many clinical settings. Recently, a self-contained chemically heated, active HME/HCH has been developed. The Thermax® Super HCH with Filter (T), available through 3CI/Critical Care Concepts Inc., combines soda sorb with standard HME material, and from the chemical reaction with exhaled carbon dioxide produces heat, increasing the delivered water content. We compared a passive HME/HCH (Gibeck® Humid Vent 2S manufactured by Louis Gibeck AB of Sweden) (G) to the T in a prospective, randomized trial. METHODS: The Human Investigation Committee permitted the study without informed consent since we were comparing FDA approved products. Patients undergoing first time, non-emergency, coronary artery bypass surgery, having good ventricular function, were randomly assigned either a standard HME/HCH or the T HME/HCH at the completion of surgery. We hypothesized that the T would increase core temperature more quickly and that this would improve coagulation and hasten extubation. Blood loss, time to extubation, body temperature, dynamic airway pressures and flows, and number of HME change outs were recorded until extubation. Quality and quantity of secretions were noted. Initial rate of temperature rise and added resistance of the humidifier at extubation was calculated. 24 patients in the G group and 22 patients in the T group completed the study. Continuous values were compared using T tests. RESULTS:

HME/HCH	Initial Temp Rise	Blood Loss	Time to Extubation	Added Resistance
Gibeck®	0.0699 °C/hr*	382 ml	8.54 hr	0.0899 $cmH_2O\ sec\ L^{-1}$
Thermax®	0.269 °C/hr*	429 ml	10.12 hr	0.0956 $cmH_2O\ sec\ L^{-1}$

*p=0.0027

Only the rate of rise of body temperature was different between the groups. No device needed changing due to accumulation of secretions. CONCLUSIONS: The Thermax® increased these hypothermic patients' core temperature three times more quickly than a standard, passive HME/HCH. Extubation time and bleeding are influenced by many factors, not just core temperature. This preliminary study suggests that the Thermax® device may be useful in hypothermic patients. Further investigation is needed to define other benefits. Secretions were not significant in any of these patients.

OF-99-006

FIO2 VARIATION WHEN DELIVERING HELIOX BY HOOD.

Elsie Collado,BS,RRT,RCP, Rick Ford, BS, RRT, RCP;
John Newhart,CRTT, RCP,
UCSD Medical Center, San Diego California

Background: Heliox has been utilized to reduce the work of breathing in pediatric patients with severe upper airway obstruction. We theorized that the high diffusion rate and the low specific gravity of Helium may result in a non-homogeneous Heliox mixture when a head hood is used as the delivery device. The clinical consequences being the potential to deliver FIO2 less than desired or measured at the inlet. **Method:** A 70/30 Heliox (HeO2) mixture was delivered into a Tenthouse hood (NOVA) at flowrates of 8, 16, and 24 lpm. The dimensions of the hood were 12"H x 12"W x 12"D. and a MiniOx III was utilized to measure the FIO2 at heights within the hood of 0, 4, 8, and 12 inches as well as input.

Results: The below table reflects the measured FiO2 at various heights in the hood at the specified liter flows.

	0 inches	4 inches	8 inches	12 inches	Input
8 lpm	20.3	19.8	22.9	27.3	30
16 lpm	19.9	18.9	27.4	28.9	30
24 lpm	19.5	21.3	28.7	30	30

Conclusion: Variations of as much as 10.5% were observed when measuring FIO2 at different heights within the hood. FIO2 readings closer to that measured at the inlet were observed when flowrates of at least 16 lpm were used and the FIO2 was measured at a height of at least 8 inches. We do not recommend the use of a hood to deliver Heliox, however if necessary FIO2 should be measured at the height of the patient's mouth, flowrates may have to be adjusted upward and the patient should be monitored by an oximeter to alert the clinician to episodes of O2 desaturation.

OF-99-012

OXYGEN CONSERVATION DEVICES IMPROVE PORTABILITY AND REDUCE THE COST OF CARE FOR AMBULATORY HOME OXYGEN THERAPY PATIENTS

J. Stegmaier RRT, J. Lewarski RRT, G. Frate-Mikus, RRT, Hytech Homecare, Mentor, Ohio

Background: Decreases in Medicare oxygen reimbursement (30% since 1997) have placed a strain on suppliers trying to meet patients portable oxygen needs. Recent advances in the development and availability of oxygen conserving devices (OCD) may offer oxygen suppliers a cost-saving adjunct to compressed gas portable oxygen systems. OCD's are designed to ration compressed oxygen by delivering flow during the patient's inspiratory cycle only. This is achieved through a demand or time-cycled system and a pre-determined dose of O2 (varies by manufacturer). Actual gas savings will depend on respiratory rate and with some devices, tidal volume. Although sound in theory, there is little published data supporting clinical applications and actual cost savings. We developed an OCD clinical trial protocol based on the AARC CPG for oxygen therapy in the home. We used the DeVillbis EX2000D PulseDose® Conserving Device, and the Puritan Bennett Companion® CR 50 Conserving Device. **Method:** Over a period of one year, 49 patients were evaluated for the use of an OCD. Patients were identified by their high utilization of cylinders (>4/week) or use of liquid oxygen (LOX) for portability. All patients had ordered liter flows of 2 lpm. OCD trial criteria was limited to stable, ambulatory patients with a baseline respiratory rate (RR) <40 bpm and resting and ambulatory Sa02> 90% on their prescribed oxygen. A physician's order was obtained for the clinical assessment and trial of the OCD. The patient was trialed first on the PulseDose® OCD at their prescribed O2 liter flow (unit in the pulse mode). The following acceptable OCD trial criteria was measured at rest and with ambulation: ability to trigger the unit with inspiration, a change in Sa02 of 2% or less, Sa02 remained > than 90% and a RR between 6-40 bpm. If the patient failed any of the criteria using the PulseDose®, the trial was repeated using the Companion®(following the same protocol). PulseDose® was our device of choice due to its greater conserving ability and standard nasal cannula use.

Device	# of Patients	Percentage	Weight of System	Avg. Portability on 2 lpm (based on mfg. Specs)
PulseDose®	33	67%	8.6 lbs	10-12 hours
Companion®	11	22%	8.6 lbs	6-8 hours
LOX Portable	2	4%	8.6 lbs	6-8 hours
Std. Regulator	3	5%	8.0 lbs	3 hours

All cylinder weights and approximate hours of portability are based on aluminum "D" cylinders filled to 2000 psi. Liquid portability is based on a typical 1.25-liter portable unit.

Results: 44 of the 49 patient's (90%) were able to tolerate one of the OCD's as per the protocol. Of the 5 patients that failed, 2 (4%) failed due because of O2 desaturation and 3 (6%) failed due to an inability to trigger either device. Conclusions: Oxygen dependent patients able to tolerate the use of an OCD will achieve extended oxygen portability. LOX patients gained an average of 2-3 hours (when using the Pulse Dose®) and cylinder patients gained an average of 7-9 hours. In all cases, little or no additional weight was added to the portable system. Patient satisfaction was measured via a telephone survey. 98% of the patients (43 of 44) felt the OCD improved their overall quality of life, due in part to the improved portability as well as a significant decrease in the number of deliveries for oxygen. Deliveries to supply oxygen to this study group decreased by 64% (176 deliveries to 63 deliveries per month). With our average cost of an oxygen delivery at $40.00 and an average OCD acquisition cost of $425.00, we project that the effective and appropriate selection and use of an OCD in this patient group will result in an estimated annual savings of over $35,540.

OF-99-020

EFFECTS OF OXYHOOD GEOMETRY AND OXYGEN CONCENTRATION ON NO_2 PRODUCTION

Michael Tracy, RRT, Robert Chatburn, RRT, FAARC
University Hospitals of Cleveland, Ohio

BACKGROUND: Previous studies at our institution suggested that nitric oxide (NO) can be delivered to an oxyhood with acceptable levels of nitrogen dioxide (NO_2) using a large Nova Tent House (Nova Health Systems, Blackwood, NJ) at a constant F_IO_2. The purpose of this study was to determine if (a) hood geometry effects NO_2 levels (b) increasing F_IO_2 results in unecceptable levels of NO_2 production and (c) oxyhood delivery of NO with poses an environmental threat. **METHODS:** Three different oxyhoods were set to receive $F_IO_2 = 0.40$ at a total flow of 15L/m. NO was then introduced at 40 ppm. Hood brands were: ICN Pharmaceutical Ribavirin hood (ICN Pharmaceuticals, Costa Mesa, CA), "Oxydome" (Nascor, Australia) and the 7"x7"x7" (small) Nova Tent House. An INO-vent (INO Therapeutics, Clinton, NJ) was used to inject NO and monitor NO, NO_2 and O_2. The INOvent was calibrated according to the manufacturer's Instructions. One measurement was made for each experimental condition after a 5 minute stabilization period. The injector module was placed on the inlet side of the humidifier and the sample line was suspended in the center of each hood. Environmental exposure to NO and NO_2 was assessed by sampling at 10, 30 and 60 cm away from the head opening of the hood. Peak exposure level (PEL) was obtained by lifting up the hood and measuring the highest NO/NO_2 concentrations at 30 cm. The effect of increasing F_IO_2 on NO_2 production was evaluated for the large Nova hood only as the worst case scenario. F_IO_2 was varied in 0.10 increments from 0.40 to 1.00. Correlation was assessed with Pearson product moment correlation and linear regression. **RESULTS:** Measured NO levels ranged from 36 to 38 ppm with a resultant F_IO_2 ranging from 0.36 to 0.28. NO_2 was 0.7 ppm for the ICN hood and 0.5 ppm for the other two. NO/NO_2 data outside the hoods are shown below. The correlation between F_IO_2 and NO_2 was 0.983 ($p < 0.0001$); FiO2 = -0.245 + (0.444 * NO2), $R^2 = 0.967$, (assumptions of normality and constant variance validated).

Environmental Exposure Data

	10 cm	30 cm	60 cm	PEL@30cm
ICN	33 / 0.6	0.8 / 0.0	0.3 / 0.0	2.5 / 0.0
Oxydome	30 / 0.4	1.3 / 0.0	0.5 / 0.0	3.8 / 0.0
Nova small	25 / 0.2	0.6 / 0.0	0.3 / 0.0	1.7 / 0.0
Nova large	37 / 0.9	1.5 / 0.0	0.6 / 0.0	3.5 / 0.0

The ICN scavenging system did not decrease environmental exposure to NO/NO_2. **CONCLUSIONS:** All oxyhoods satisfactorily deliver NO/O_2 mixtures. Scavenging is not necessary. At any significant distance from the hood NO and NO_2 values are well below OSHA guidelines (NO TWA = 25ppm, NO_2 = 3ppm, NO PEL = 25 ppm and NO_2 STEL = 5ppm). Higher FIO_2 places the patient at increased risk of NO_2 exposure. Respiratory Care departments delivering NO/O_2 mixtures via oxyhood should establish preset mixture limits to avoid placing their patients at increased risk.

OF-99-021

DECREASING COSTS IN THE VA SAN DIEGO HOME OXYGEN PROGRAM

Marshelle Ramler, RRT, Andy Mosley, CRT, Angela Wang, MD-VA San Diego Healthcare System (VASDHS).

BACKGROUND: Containing costs is of increasing concern in today's Healthcare environment. In March 1998, a full-time coordinator was hired to manage the VASDHS Home O_2 Program. Previously, the position had been an unstructured, minority-time assignment. There were 126 patients on the program and total monthly expenditures were $16,476. The average cost per patient was $131. Method: A procedure of monthly review was implemented to compare each patient's Rx with the monthly invoicing to determine if the quantity of tanks on hand was appropriate for the patient's Rx and level of activity. This initial review revealed an excess of supplies by many patients. The use of liquid oxygen (LOX) systems in some instances also contributed to the high cost. A database was created to track monthly compressed gas usage and determine the number of tanks the patient typically used in a one-week period. The results were discussed with each patient, and "on-hand" limits were established. Patients were advised that empty tanks could be exchanged for full ones as needed. This reduced the monthly costs by decreasing the number of unused rental tanks. Limits were communicated to the contract vendor and an even-exchange policy was established. To assure compliance with guidelines, the coordinator now approves all changes in patient equipment. The use of oxygen conserving cannulae and pulse dose delivery systems, when appropriate, also reduced monthly oxygen consumption. Furthermore, because purchasing concentrators has proven to be more economical than renting, LOX systems were exchanged for VA owned oxygen concentrators whenever possible. Monthly expenditures and number of patients were tracked for a one-year period. Results: From March 1998 to March 1999, the monthly average cost per patient was considerably reduced from $131 to $101 while the patient base grew from 126 to 173 veterans. Because equipment modifications are ongoing, this number is expected to decrease further. These savings offset the expense incurred by hiring a full-time coordinator. Conclusion: The attention provided by a full-time coordinator allowed for a significant decrease in monthly average cost per patient *without compromising patient care*. As a result, the VASDHS could redirect its resources and provide oxygen for its growing number of patients. EXPERIENCE: Presenter is an RRT with 15 years clinical experience in acute care facilities including 12 at the VASDHS.

OF-99-071

AN EVALUATION OF AN ACTIVE HEAT AND MOISTURE EXCHANGER THE "HME BOOSTER™"

J M Anthony* V Knowles MBChB and G R Park MD, DMedSci, FRCA
John Farman Intensive Care Unit, Addenbrooke's Hospital, Cambridge England and * Tomtec Vogelkerslaan 20, 2950 Kappellen, Belgium.

Background: In the critically ill or anaesthetised patient adequate humidification is essential if the trachea is intubated for a long time. Under-humidification may result in airway plugging and damage to the airways. Excessive humidification can lead to profuse secretions. Fixed performance humidifers, such as Heat and Moisture Exchanger (HME) and heated water baths (HWB) take no account of patient variability. We have previously reported an Active HME (aHME)[1] and now report an evaluation of the similar commercially available model, the HME booster. This aHME comprises a conventional HME. Between this and the tracheal tube a T piece is fitted. Into the T piece a heated plug is fitted, over the end of which is a Goretex™ membrane. Between the heater and the membrane water is injected. The heater vapourises the water which passes through the membrane. The amount of water vapour passing through the membrane depends on the humidity of the airway gas; regulating the flow of water into the device. **Method:** A similar method to that used before[1] was used. A ventilator delivering a 20°C, tidal volume 1L, frequency 10 breaths/a min into a test lung at 34°C (1S0 9360) for 12h was used. In the circuit the humidifer as shown in the table was placed and the variables shown measured. **Results:**

	H_2O loss	Temperature (°C)	
	g/h	Insp.	Exp.
Without HME	8.9	21.3	34
HMEF DAR Hydrobag 5"	4.5	29	34.3
DAR Hygrobag "S"	2	34.1	35.8
HWB (Fischer Paykel)	3.3	33.2	35.4
with heated hoses, main setting 33°C, Chamber setting -1°C			
HWB (Fischer Paykel	2.3	34.8	36.6
with heated hoses. main setting 36°C, chamber setting -1°C			

The aHME reduced water loss from the circuit and had the highest temperatures except for the HWB at its higher setting. **Conclusion:** This aHME offers adaptable humidification. It can give equivalent humidification to a HWB. The cost of each disposable part for the aHME is £3.29, while the cost of disposables for the HWB is £21. Initial capital costs are aHME £49.50, HWB £1,300. The aHME is cheaper to buy and run and in the laboratory as effective as the HWB. 1. F Kapadia et al Brit J. Anaesth 1992;69,640

OF-99-090

EVALUATION OF HEAT MOISTURE EXCHANGERS AS A METHOD OF HUMIDIFYING INSPIRED GASES IN THE PEDIATRIC CARDIOTHORACIC INTENSIVE CARE UNIT.

Mary Dekeon, RRT, Thomas Kulik, MD, Paul Reynolds, MD, Cheryl Lathrop, RRT. University of Michigan Medical Center, Ann Arbor, MI.

INTRODUCTION: Heat Moisture Exchangers (HME's) have been proven to be effective in conditioning inspired gases in mechanically ventilated adult populations. The reported advantages of HME's include; cost reduction and decreased bacterial colonization. Few studies have been conducted in pediatric infants who require short-term (<96 hours) mechanical ventilation following cardiothoracic surgery. The purpose of this study is to evaluate the safety and efficacy of HME's in mechanically ventilated pediatric patients. METHODS: All mechanically ventilated pediatric patients, weighing greater than 10 kilograms, undergoing cardiothoracic surgery at the University of Michigan Medical Center were considered candidates for this study. Patients were excluded if any of the following conditions were encountered; extremely thick, tenacious secretions, >20% cuff leak, decreased ability to maintain body temperature or increased need for prolonged (>96 hrs) mechanical ventilation. Patients were sequentially enrolled, and a non-heated ventilator circuit with HME was employed during and following surgery. Each patient was monitored to document presence or absence of adverse events or complications potentially associated with the use of HME's and non-heated ventilator circuits. RESULTS: No adverse events or complications were observed in any of the 32 patients enrolled in this study. Two patients were changed from an HME to a heated wire circuit during the study. One patient required prolonged mechanical ventilation and 1 patient developed a significant (>20%) cuff leak. The average duration of mechanical ventilation in this study population was 13.05 hours. Our average cost savings associated with the use of non-heated ventilator circuits + HME was $20.54 per patient compared to heated ventilator circuits alone. Our department cost benefit analysis projects an annual saving of $6,162.00 associated with non-heated circuits + HME's in this population. CONCLUSIONS: HME's are a safe and cost effective method to condition inspired gases in mechanically ventilated pediatric cardiothoracic patients. Further studies are warranted to evaluate the additional potential advantage of decreased bacterial colonization in this population.

OF-99-079

SEVERE METHEMOGLOBINEMIA IMPAIRING EFFECTIVE OXYGEN DELIVERY: A CASE REPORT

Jeffrey A. Faatz BA BS RRT, Neil R. MacIntyre MD Duke University Medical Center Durham , North Carolina

Case report: A 57 year-old black female with metastatic stage IV leiomyosarcoma developed altered mental status, tingling, and lethargy following a chemotherapy regimen consisting of mesna, ifosfamide, adriamycin, and dacarbazine. Upon exam, the patient was in no apparent respiratory distress but there was a marked "chocolate" hue to the patient's lips and mucous membranes. The SpO_2 while breathing room air was 88-94% and this remained unchanged despite the application of a 6 liter nasal cannula. The arterial blood gas (ABG) sample was visibly dark brown and revealed: pH 7.49/$PaCO_2$ 29 torr/PaO_2 56 torr with a measured SaO_2 of 46.2% and a methemoglobin level (MetHgb) of 49.8%. 100% oxygen was given and repeat ABG revealed: pH 7.51/$PaCO_2$ 27 torr/PaO_2 346 torr with a measured SaO_2 of 42.2% and a MetHgb of 56.6%. The patient was transferred to the Intensive Care Unit and intubated for airway protection. Intravenous methylene blue was administered and an ABG thirty minutes later showed: pH 7.49/$PaCO_2$ 27 torr/PaO_2 475 torr with a measured SaO_2 of 67.5% and a MetHgb of 31.3%. Over the next twelve hours the methemoglobin level decreased to 4.2% and within 24 hours it was within normal limits. The patient was extubated and transferred back to the general care unit.

Discussion: Methemoglobin is an abnormal hemoglobin incapable of carrying oxygen because the iron molecule is in the ferric [Fe 3+] rather than in the ferrous [Fe 2+] form. Methemoglobinemia is rare and its development is usually secondary to certain drugs administered to the patient. In this case, no drugs reported to be related to MetHgb were administered but we suspect ifosfamide since it is closely related to cyclophosphamide, a drug known to produce MetHgb. Methemoglobinemia presents two important problems for respiratory care practitioners (RCPs): First, MetHgb impairs oxygen delivery because increased levels of methemoglobin decrease the overall oxygen supply and because the oxygen dissociation curve is shifted to the left, which inhibits the release of oxygen from the hemoglobin molecule. Increasing FiO_2 will increase dissolved O_2 content but this is no substitute for methylene blue administration to eliminate MetHgb. A second problem for RCPs is that standard pulse oximeters have difficulty distinguishing MetHgb from oxyhemolglobin. Note that in this patient, pulse oximetry showed near normal values for SpO_2 even though the measured SaO_2 was less than 50%. Pulse oximetry thus cannot be relied upon to rule out MetHgb.

OF-99-105

LABORATORY EVALUATION OF ULTI-MIST® HEAT AND MOISTURE EXCHANGERS

Richard Branson RRT, Robert Campbell RRT, Kenneth Davis Jr. MD Department of Surgery, University of Cincinnati Medical Center, Cincinnati, OH. 45255

Background: Hygroscopic heat and moisture exchangers (HHME) are frequently used to condition inspired gases during mechanical ventilation. We evaluated the moisture output (mg H2O/L), resistance (cm H2O/L/s), and deadspace (mL) of 2 new HHME and 2 new HHME filters (HHMEF). **Method:** A patient lung model consisting of a cascade humidifier, temperature controller, 2 test lungs, and a series of tubing and one-way valves to separate inspired and expired gases was constructed as per ISO 9360. The model was ventilated using compressed air at: 1) V_T = 500 mL and f = 20 b/min and 2) V_T = 1000 mL and f = 10 b/min. Ventilation was accomplished using a square inspiratory flow pattern and I:E of 1:2. The lung model was controlled to maintain an expired gas temperature of 34°C. The model was weighed before and after ventilation with and without the HHME in line to determine water loss in mg/L. Moisture output (MO) was determined using the equation (MO = 1 - [water loss in mg with the HHME/ water loss in mg without the HHME] x 37.6. Resistance was measured by delivering a flow of 1.0 L/s through the device via a rotameter and measuring the pressure drop with a differential pressure transducer. Deadspace was determined by filling the devices with water from a calibrated flask. Three of each device were tested. **Results:** Results are shown in the table as mean ± SD.

DEVICE	Moisture Output (mg H2O/L)		Resistance (cm H2O/L/s)	Deadspace (mL)
	500 mL	1000 mL	After use	
MS-121 HME/F	32.6 (1.2)	30.8 (1.4)	2.01 (0.8)	95 (3)
MS-120 HME	32.2 (1.4)	30.7 (1.1)	1.30 (0.4)	94 (4)
MS-111 HME/F	30.5 (1.0)	29.5 (1.1)	2.77 (0.9)	53 (2)
MS-110 HME	30.3 (1.1)	29.0 (1.2)	1.55 (0.6)	52 (4)

MS-120 = Medisize Ulti-Mist HME ICU, MS-121 = Medisize Ulti-Mist HME/F ICU, MS-110 = Medisize Ulti-Mist HME ICU, MS-111 = Medisize Ulti-Mist HME/F ICU (King Systems, Nobelsville, IN)

Conclusions: New HHME(F) devices are introduced frequently. Evaluation of these devices using standard test protocols, allows independent comparison of device characteristics. The devices tested meet the AARC guidelines proposed in the Consensus Conference on Mechanical Ventilation. The HHMEF devices have a significantly higher resistance than the HHME devices, despite no increase in MO. No device exceeded the maximum resistance of 5 cm H2O/L/s suggested by ISO. RCP's should appreciate the characteristics of the HHME(F) devices they use.

OF-99-118

Survey of Hospitals Regarding Central Oxygen Supply Systems: An "O_2K" Problem?

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Background: As an essential hospital facility, the central oxygen supply system should be designed with features allowing back-up and/or redundancy in the event of system failure. For example, the availability of a back-up supply would be especially important if the main supply line from the bulk liquid storage to the main hospital were a single feed line at risk of being disrupted by mishaps such as road construction, natural disasters, etc. As part of an organized institutional review of The Cleveland Clinic Hospital in-patient central oxygen supply system, we undertook a survey of all hospitals in two Ohio cities (Cleveland and Columbus) to determine the characteristics of hospital central supply systems in 1999. **Methods:** The questionnaire was developed and completed by structured telephone interview during calls placed to managers of facilities engineering departments in all hospitals in the greater Cleveland and Columbus (Ohio) metropolitan areas. To encourage candid responses to the phone interview, respondents were assured that institutional identifiers would not be presented in published reports. The questionnaire addresses the type of primary and reserve oxygen sources in the hospital, whether a back-up system exists, and if so, in what configuration. The questionnaire also addresses whether any unplanned interruption or other problem (such as contamination of the piped-in oxygen supply) had ever occurred in the facility. When the manager of the hospital facilities department could not be reached, follow-up calls for questionnaire completion were placed to the hospital directors of respiratory care. **Results:** Of the 35 eligible hospitals, surveys have been completed in 23 (66%) to date. The mean number of beds in the hospital surveyed was 336 (± 191 SD) and the original construction dates of the surveyed hospitals ranged from 1887 to 1982. Of the 23 hospitals, all have central oxygen supplies that rely on a bulk oxygen system consisting of a primary liquid reservoir with an additional liquid reservoir or manifolded gas cylinders functioning as a reserve. Eighteen (78%) of those surveyed have the reserve supply, liquid or manifolded cylinders, at the same location as the primary liquid vessel. The supply lines of these contiguous primary and reserve containers join proximal to entering the hospital structure, so that the main and the reserve supply of these eighteen hospitals are dependent upon a single length of pipe. In the remaining 5 institutions, 4 have manifolded cylinders that have a physically separate feed line and 1 has no on-line back-up but relies on portable cylinders. Presented with the possibility of an interruption of service of the liquid bulk supply, many of the hospitals surveyed (14/23, 61%) depend on the ability of their liquid oxygen supplier to provide a portable tanker and evaporator to be connected to an interface on the facility exterior. Respondents estimated that it would take 45 minutes to 2 hours before a tanker could be in place and on-line. Finally, of the 23 hospitals surveyed, 4 (17%) reported having experienced temporary interruption in service from the bulk liquid supply. In each of these incidents, a contractor had damaged the incoming supply line. Conclusions: 1. Most of the hospitals in these two urban areas use bulk liquid oxygen systems as the main central supply source, with some providing manifolded cylinders as back up. 2. Mishaps regarding the bulk oxygen central supply system were reported by 17% of responding institutions and all involved interruption of the incoming supply line. 3. The fact that most main and reserve tanks were contiguous and fed through a single line to the hospital facility suggests ongoing risk for interruption of an oxygen supply by line mishaps (e.g., construction). 4. Contingency planning to lessen the risk of an interrupted supply should involve back-up systems with physically separated feed-lines, as well as banks of manifolded cylinders along the course of the main hospital oxygen circuit line.

OF-99-129

COMPARISON OF THE USEFUL LIFE OF OXIMETRY SENSORS

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Background. The purpose of the study was to compare the useful life of Datex-Ohmeda adult OxyTip oximetry sensors (A-Tips) to that of Nellcor Puritan Bennett D-25 Oxisensor II sensors on adult patients undergoing long-term SpO2 monitoring.

Method. Patients selected to participate were adult candidates for continuous SpO2 monitoring of at least 72 hours. All participants were intensive care patients. For the comparison, both of the two sensors being studied were applied simultaneously to each patient on opposing extremities (i.e., Datex-Ohmeda A-Tip to right index finger, Nellcor Puritan-Bennett D-25 to left index finger). When reapplication of a sensor to a different digit was required, the other brand of sensor was also reapplied comparably. Sensors were examined on a regular basis for signs of wear and compromised adhesiveness. When a sensor could no longer be reapplied successfully, it was removed and its lifespan in hours recorded. Clinicians documented specific reasons for terminating use of the sensor. At that point, the opposing brand sensor continued in use alone on the patient until it became unusable, and its lifespan and reason for removal were also recorded.

Results. As of the date of abstract submission, a total of 4 Datex-Ohmeda A-Tip and Nellcor Puritan-Bennett D-25 sensors were tested. The average lifespan of the Datex-Ohmeda A-Tip proved to be 127.5 hours. The average lifespan of the Nellcor Puritan-Bennett D-25 sensor was 83.5 hours. The lifespan range of the Datex-Ohmeda A-Tip was from 46.25 hours (shortest) to 211.5 hours (longest). The lifespan range of the Nellcor Puritan-Bennett D-25 was from 46.25 hours (shortest) to 151.25 hours (longest). This study will be ongoing until at least 25 sensors of each brand have been tested.

Experience. The author and participating respiratory care clinicians are experienced and knowledgeable regarding the benefits and methods of monitoring SpO2 using pulse oximetry. All had prior familiarity with both Datex-Ohmeda and Nellcor Puritan-Bennett oximeters and sensors.

Conclusions. In the preliminary results of this evaluation, the Datex-Ohmeda A-Tip sensor proved to have an average life span approximately 1.5 times longer than that of the Nellcor Puritan-Bennett D-25 sensor. While full cost comparisons would need to take into account other factors, such as the negotiated price a health care organization is paying for all oximetry-related equipment and supplies, the study indicates that the Datex-Ohmeda A-Tip may be more cost-effective per patient than the Nellcor Puritan-Bennett D-25 sensor.

OF-99-141

COMPARISON OF TRIGGERING SENSITIVITY IN FIVE DEMAND OXYGEN DELIVERY SYSTEMS (DODS).

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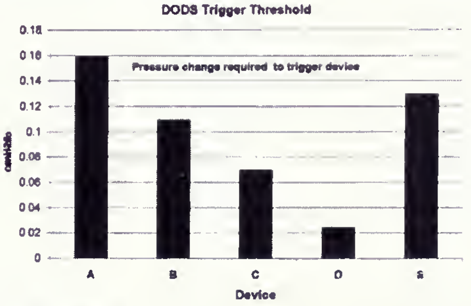
Introduction: A DODS delivers oxygen only as patient flow demand triggers the device. Consequently triggering sensitivity, or trigger threshold may be important to oxygen delivery. Higher trigger threshold (greater effort required) may result in missed breaths or late oxygen delivery. To determine whether triggering sensitivity might vary between DOS models, we constructed a mechanical model and evaluated five commercially available devices. **Methods:** One side of a mechanical test lung was "driven" with a linked ventilator. The second, "breathing" side was connected to a simulated, machined "nose", in which a standard nasal cannula was placed. The cannula was connected to each DODS unit. A pressure transducer coupled with a computer data acquisition system was used to monitor the pressure at the outlet of the DODS. Peak Inspiratory Flow (PIF) was controlled on the ventilator to vary the simulated inspiratory effort. Lower PIF resulted in lower pressure changes in the cannula. Starting from a setting that consistently triggered the DODS, PIF was gradually reduced to a level at which the device was not triggered. By monitoring the pressure in the cannula, the precise minimum pressure change that triggered the device (trigger threshold) was determined.



Results: The average trigger threshold observed was 0.10 cmH2O. The full range of trigger threshold was 0.025 to 0.16 cmH2O, with device D being the most sensitive, and device A the least. **Conclusions:** While clinical implications cannot be directly drawn from this data, trigger sensitivity variability exists between devices. Patients with shallow breathing patterns, those who breath through their mouth, or those using a DODS while sleeping may experience reduced oxygen delivery due to missed breaths or late delivery.

OF-99-178

MEASURING SUBATMOSPHERIC OXYGEN CONCENTRATIONS

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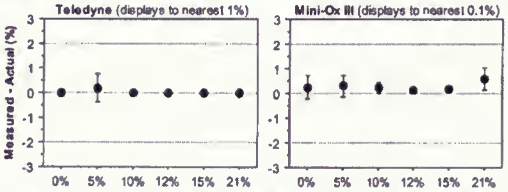
INTRODUCTION: The immediate survival of infants with hypoplastic left heart syndrome (HLHS) is dependent upon the success in achieving several therapeutic goals. These are: (1) maintaining patency of the ductus arteriosis, (2) assuring adequate mixing of blood at the atrial level, and (3) establishing and maintaining a balance between systemic and pulmonary blood flow at or near unity. In accomplishing the final goal, different ventilatory strategies have been used to alter the physiologic modifiers of pulmonary vascular resistance and to thus maintain balanced circulation. One method is breathing small amounts of carbon dioxide (Respir Care 1994;39:1039). Another strategy employs oxygen delivered at concentrations below atmospheric pressure to achieve this goal. However, commercial oxygen analyzers are specified for use within the range of 0 21 to 1.0 fractional concentration of inspired oxygen (FiO_2), leaving the accuracy and precision of subambient oxygen delivery systems somewhat uncertain. The purpose of this study was to evaluate the performance of oxygen analyzers below this specified range in an effort to improve the regulation of subambient oxygen delivery systems. **METHODS:** Two commercial brands of analyzers were used in the study: the TED-190 (Teledyne Brown Engineering) and the Mini-Ox III (Mine Safety Appliances Company). Five new analyzers of each model were tested. After calibration with 100% oxygen, all 5 analyzers of the same model were simultaneously exposed to precision blended gases at 6 different concentrations of oxygen. Steady state was maintained for at least 2 minutes at each concentration before readings were recorded. Calibration was verified at 21% oxygen between each level. **RESULTS:** The maximum difference between measured and known oxygen concentrations was 1%. Data below are expressed as the mean difference (as % of full scale) with error bars representing the 95% confidence interval. The dotted lines represent the manufacturers' total error specifications.



CONCLUSION: These two commercial oxygen analyzers maintained linearity and accuracy from 0 to 21% oxygen at ambient pressure and temperature. All measurements were within the manufacturers' error specifications. The Teledyne units were modified by the manufacturer so that the alarm thresholds could be adjusted down to 0%. Because even minor fluctuations in F_IO_2 can have a significant effect on patient condition, the Mini-Ox III, with readings to the nearest 0.1%, might allow more precise control.

OF-99-189

ACCURACY OF THE NONIN ONYX 9500 PULSE OXIMETER FOR THE MEASUREMENT OF ARTERIAL OXYGEN SATURATION.

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INTRODUCTION: The Nonin Onyx 9500 finger pulse oximeter (Nonin Medical, Inc., Plymouth, MN) is a miniature (3.3x3.3x5.7 cm), lightweight (60 gm) device for the measurement of arterial oxygen saturation (SpO2). We compared the performance of the Nonin Onyx 9500 system to oxygen saturations (SaO2) obtained via arterial blood co-oximetry using the IL 682 (Instrumentation Laboratory, Lexington, MA) and SpO2 determined using the Criticare Systems Inc. (CSI) model 503 pulse oximeter (Criticare Systems, Inc., Milwaukee, WI). **METHODS:** Sixty-five hospitalized patients requiring arterial blood gas analysis were assessed for SpO2 using the Nonin Onyx 9500 and CSI 503. SpO2 values and arterial blood samples were obtained concurrently. Mean SpO2 and SaO2 values were compared using the t-test for dependent samples. Pearson-product moment correlations were calculated and regression equations were evaluated to determine the slope and intercept of the regression line for paired values for SpO2 and SaO2. Means, standard deviations (SD) and ranges were also calculated for the differences between the paired results between instruments to provide measures of bias and imprecision. Limits of agreement were then calculated as the mean difference +/- 2 SD. **RESULTS:** Mean (SD) oxygen saturations obtained using the three instruments were:

	Nonin Onyx 9500	CSI 503	IL 682
Oxygen Saturation	93.6 (3.75)	93.14 (3.95)	93.97 (3.23)

There were no significant differences in mean oxygen saturations obtained using the Nonin Onynx 9500 and IL 682 (t = 1.41; p = .16). There were significant differences for the Nonin when compared to the CSI 503 (t = 2.21; p = .03) and the CSI 503 when compared to the IL 682 (t = 2.59; p = .01). There were significant correlations between values obtained using the Nonin when compared to the IL 682 (r = .83; p < .00001) and the CSI 503 (r = .91; p < .00001) and significant correlations between the CSI 503 and IL 682 (r = .76; p < .00001). Regression equations were:

Nonin Onyx SPO2 = 3.2627 +.96135 x IL 682 SaO2
Nonin Onyx SPO2 = 13.612 + .85881 x CSI SpO2

The mean (SD) difference for the paired results (bias) for the IL 682 and the Nonin was .3692 (2.11) with a range of –6 to +9%; for the CSI 503 and Nonin the mean difference was -.4615 (1.69) with a range of -6 to +3% and for the IL 682 and CSI 503 the mean difference was .8308 (2.59) with a range of –7 to +12%. The limits of agreement between the IL 682 and Nonin were –3.85 to +4.59; IL 682 and CSI 503: –4.35 to +6.01 and CSI 503 and Nonin: –3.84 to + 2.91. **CONCLUSIONS:** There was no significant difference between mean arterial oxygen saturations as measured by the Nonin Onyx 9500 pulse oximeter and the results of co-oximetry using the IL 682. SpO2 results were significantly correlated with measured SaO2. There were small, but statistically significant differences between mean oxygen saturation values obtained using the CSI 503 and both the Nonin Onyx 9500 and IL 682, however, these differences were probably not clinically important.

OF-99-197

RELIABLE PULSE OXIMETRY DURING EXERCISE TESTING.

Sally Harrington CRTT, Diannah Henderson RN, George G. Burton MD, Kettering Medical Center, Kettering, OH

Background: Motion artifact (imposed and innate) and compromised monitoring site perfusion have been thought to limit the use of conventional pulse oximetry during exercise testing (AARC Clinical Practice Guideline 8/92). The Masimo SET pulse oximeter (Masimo Corp, Irvine, CA) claims to measure SpO_2 and pulse rate (PR) during motion and low perfusion conditions but its accuracy during stress testing has not yet been reported. **Methods:** Adhesive sensors from Masimo SET and Nellcor N-200 (NellcorPB, Pleasanton, CA) pulse oximeters were attached to different fingers of the same hand on 5 adult volunteers with known lung disease. Each sensor was shielded to prevent optical cross-talk between the photodetectors. The subjects were exercised on a treadmill ergometer for efficiency testing of various oxygen conservation devices. The magnitude of exercise (duration and speed) was customized for each subject based upon the modified Borg dyspnea scale (Thorax 48:33-38, 1993) established during prior testing. Data (ECG heart rate, PR and SpO_2) were collected by a computerized data acquisition (DAQ) system. The DAQ file for each test period was analyzed after the study for data discrepancies. When either pulse oximeter displayed SpO_2 values > 5% from the other, raw waveform analysis was performed to calculate the SpO_2. This post-processing technique uses both time- and frequency-domain information to calculate the correct SpO_2 from the detected red and infrared light signals (Comp. Bio. Med. 26:143-159, 1996). Also compared for differences was the pulse oximeter's specification for PR and the ECG monitor heart rate (± 3 bpm for both devices). The frequency and duration of spurious values were tabulated. Data was statistically analyzed using the Wilcoxon Rank Sum Test and significance was assumed if $p < 0.05$. **Results:** The 5 subjects were 62 ± 10 years of age and all had oxygen dependent pulmonary disease. They performed 134 minutes of total treadmill ergometry during 13 separate tests (mean duration of 10.2 ± 1.3 minutes). There were 22 "zero outs" (SpO_2 and PR displays of zeros) and all were excluded from the calculations so as to not unduly and artificially skew the results (i.e., we biased in favor of Nellcor). The ECG heart rate ranged from 83-131 bpm.

Category	Masimo SET	Nellcor N-200	Significance
Accuracy (minutes)	129/133	101/133	Yes ($p < 0.01$)
Zero Outs	1	21	Yes ($p < 0.001$)
Range of SpO_2 (%)	87-98	73-97	Yes ($p = 0.02$)
Range of PR (bpm)	80-144	40-210	Yes ($p < 0.005$)

Discussion and Conclusions: Use of conventional pulse oximetry during exercise testing is problematic. Motion and monitoring site hypoperfusion adversely affects conventional pulse oximetry performance. 25% of the time data from the N-200 pulse oximeter was erroneous. Our findings demonstrate that the Masimo SET pulse oximeter accurately reflects SaO_2 and ECG heart rate during exercise testing of adults with lung disease. Reliable pulse oximetry during stress testing can be achieved with Masimo SET.

OF-99-221

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BI-LEVEL POSITIVE AIRWAY PRESSURE (PAP) IN PATIENTS PRESENTING TO THE EMERGENCY DEPARTMENT WITH A PRIMARY DIAGNOSIS OF CONGESTIVE HEART FAILURE.

Rebecca L. Meredith, RRT. The Cleveland Clinic Foundation, Cleveland, Ohio.

Background: The use of noninvasive ventilatory support has gained popularity over the last decade. The technique has been shown to decrease work of breathing and improve the ventilatory status of patients in acute respiratory distress (ARD) of cardiac, pulmonary, or neurologic origin. This study addresses the use of Bi-level PAP in the emergency department (ED) of an inner-city tertiary referral center on patients presenting with a primary diagnosis of CHF resulting in ARD. The aim is to evaluate the impact of Bi-level PAP on arterial blood gases, oxygen requirements, hospital admission (regular nursing floor vs intensive care unit), and avoidance of intubation. **Method:** The sample was comprised of 12 patients presenting to the ED with a primary diagnosis of CHF. Separate data collection sheets were utilized for all patients placed on the bi-level PAP system. Patients were assessed and rated on their intensity of sensation using a modified Borg Dyspnea Category Scale with 0 being nothing at all and 10 being maximal. The patients were managed by the physician and respiratory therapist in the ED with bi-level PAP settings adjusted to patient tolerance. Inspiratory Positive Airway Pressure/Expiratory Positive Airway Pressure (IPAP/EPAP) were set for patient comfort, ABG/saturation, and control of ventilation. Averages were 15/7 respectively. All patients were in the spontaneous/timed (S/T) mode with a % IPAP of 33. Breaths/minute were set two to five below the patient's spontaneous rate. All patients had continuous ECG and pulse oximetry monitoring. **Results:** Table 1 presents arterial blood gas (ABG) mean with ranges in parenthesis and dyspnea index. Table 2 presents the FiO_2/PaO_2 relationship before and after bi-level PAP. Patients requiring 100% before, achieved a higher PaO_2 after the initiation of treatment despite the machines ability to deliver an average FiO_2 of 86% with a bleed-in at 10-15 lpm. Intubation was required in two (16%) of the patients. The remaining 10 (83%) were successfully managed throughout their hospital stay with bi-level PAP. Five (42%) were admitted to an intensive care unit; seven (58%) went to a regular nursing floor. **Conclusion:** Bi-level PAP decreased the work of breathing and improved the ventilation of patients presenting to the ED with a primary diagnosis of CHF.

Table 1: ABG / Dyspnea Index

Before (n=12)	After (n=12)
pH: 7.23 (7.08-7.32)	pH: 7.32 (7.13-7.37)
$PaCO_2$: 65 (33-88)	$PaCO_2$: 53 (31 - 94)
PaO_2: 62 (42-102)	PaO_2: 76 (56 - 174)
% Sat: .84 (.68-.95)	% Sat: .91 (.87-.99)
Dyspnea index: 7	Dyspnea index: 3

Table 2: FiO_2/PaO_2

Before	After
1.00/64 (n=6)	.86/90
.50/59 (n=1)	.50/66
.35/60 (n=5)	.35/61

OF-99-002

COMPARISON OF WEANING PARAMETERS VIA EXTERNAL SPIROMETRY VERSUS CPAP/FLOW-BY MODE OF A MECHANICAL VENTILATOR.

Daniel Ray, M.D., Kenneth Miller, RRT, Thomas Wasser, PhD., Kathy Baker, RN, Marsha Becker, RRT, Frederick Wieand, RRT, Uma Bhatt, RRT Lehigh Valley Hospital. Allentown, PA, USA, 18105.

Weaning Parameters (WP) to assess readiness for liberation from mechanical ventilation are typically measured with a hand-held spirometer/manometer. Flow-by triggering on newer ventilators has allowed WP to be measured through the "internal" circuitry of the ventilator. **Objective:** Determine differences between WP as measured by the external spirometer/manometer (EXT) compared to the "internal" tachometer/manometer (INT) of the Purittan-Bennen(PB)7200 ventilator. **Methods:** This study was conducted in a 16 bed intensive care unit (ICU). 67 sets of WP were measured by each method in 49 patients who underwent WP measurement as part of their medical care. WP measures included respiratory rate (f), tidal volume (Vt), minute ventilation (VE), Vital Capacity (EVC), maximal inspiratory pressure (MIP) and respiratory rate to tidal volume ratio (f/Vt). EXT and INT were measured sequentially in each patient so that patients served as their own controls. Paired t-tests were used to determine differences between methods. **Results:** No significant differences ($p>0.4$) were found between INT and EXT WP methods for f (26.2 vs 24.6), Vt (.551 vs .611), VE (8.91 vs 8.71), EVC (1.1 l vs 1.01 l), or the f/Vt ratio (104 vs 103). The maximal inspiratory pressure (MIP) was significantly lower with the EXT method compared to the INT method (-21 cm H_2O vs -32 cm H_2O, $p< .001$). No adverse events were recorded. **Conclusion:** With the exception of MIP, obtaining weaning parameters through the internal circuitry of the PB7200 ventilator is safe and reliable. Additionally, it has the potential to decrease costs through reduced equipment use and may also reduce the risk of nosocomial pneumonia by maintaining a closed ventilation system.

The Dexter F. and Dorothy H. Baker Fund

OF-99-014

A COMPARISON BETWEEN THE SYRINGE METHOD AND A VENTILATOR BASED ALTERNATIVE FOR OBTAINING STATIC PRESSURE VOLUME CURVES.

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BACKGROUND: Static pressure volume (PV) curves are essential for the implementation of lung protective strategies reported in the literature. The current "gold standard" of using a calibration syringe for curve generation is problematic. An important limitation to more widespread use of static PV curves is related to the difficulty in their generation and their lack of reproducibility. We want to determine whether static PV curves comparable to those generated with a calibration syringe, could be produced without removing our patients from the ventilator.

METHOD: Using a mechanical lung model, inspiratory static PV curves were generated. A mechanics monitor (Novametrix Cosmo+) was attached inline with the circuit and interfaced to a laptop computer for data collection. Inspiratory PV curves were generated with a three-liter calibration syringe and compared to those generated using four commercially available ventilators (Bear 1000, Dräger Evita, Servo 900c, and Adult/Pediatric Star 2000). The ventilators were set to deliver 50ml VT, I:E of 1:3 and a rate of 40-60 bpm. A ball valve assembly was placed inline before the exhalation valve to allow for breaths to be stacked in the lung model.

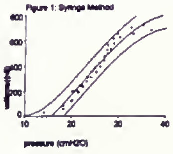
Figure 1: Syringe Method

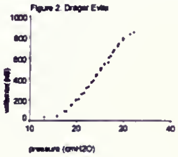
Figure 2. Drager Evita

RESULTS: Cubic regression lines provided the best fit for the data obtained by each of the syringe and ventilator-based techniques and in each case the R-square was >95%. The 95% prediction interval was plotted for the syringe-generated breaths, and is illustrated in Figure 1. The curves generated by each of the ventilators fell within this prediction interval (see example Figure 2), indicating good approximation of the syringe method by each of the ventilators.

EXPERIENCE: While static pressure volume curves are a valuable clinical tool generation of these curves is sometimes very difficult in the clinical setting.

CONCLUSION: The curves generated via the ventilator method were essentially the same as the syringe curves and did not seem to be as operator dependent. Increments were less variable and curves were more easily repeated. In the clinical setting this method allows static PV measurements to be obtained while maintaining oxygen delivery and minimizing interruption of patient ventilation.

OF-99-032

DECREASING THE DURATION OF MECHANICAL VENTILATION THROUGH THE USE OF PROTOCOL-DIRECTED WEANING

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Introduction: Mechanical ventilation (MV) is one of the most common forms of medical therapy administered in the intensive care unit (ICU). Shortening the duration of MV decreases the incidence of ventilator-associated complications and may decrease both ICU and hospital length of stay. We sought to evaluate the use of protocol-guided weaning by nurses and respiratory therapists to accomplish rapid and safe extubation of critically ill patients.

Materials and Methods: Phase 1 consisted of a prospective data collection of baseline ventilator information in the NeuroTrauma ICU of a 600-bed tertiary referral center with level 1 trauma center for patients admitted from October 1997 through February 1998. An algorithm for directed weaning by nurses and respiratory therapists was then developed by a multidisciplinary team and was instituted in July 1998 (phase 2). Data was prospectively obtained for comparative analysis from July 1998 through February 1999. The primary outcome measure was the duration of MV from tracheal intubation until discontinuation of ventilation.

Results: There were 93 patients with MV in phase 1 and 164 in phase 2. The average APACHE II score was 17.1 in phase 1 and 14.1 in phase 2. The average time of MV prior to first extubation was reduced from 106 hours in phase 1 to 88 hours in phase 2. Re-intubation rate was 9% in phase 1 and 6% in phase 2. Total time of MV was 227 hours in phase 1 and 113 hours in phase 2. ICU length of stay and hospital length of stay were reduced from 12.0 days and 20.3 days to 7.5 and 15.0 days, respectively. Hospital mortality remained the same (27% versus 28%).

Conclusions: Protocol-guided weaning of mechanical ventilation, as performed by nurses and respiratory therapists, is safe and leads to extubation more rapidly than physician-directed, non-algorithmic weaning. With more rapid extubation, both ICU and hospital length of stay are reduced.

OF-99-033

INDEPENDENT LUNG VENTILATION UTILIZING TWO ASYNCHRONOUS PURITAN BENNETT 7200AE VENTILATORS IN THE PRESSURE CONTROL VENTILATION MODE.

Kenneth Miller, B.A., RRT, Dr. Michael Pasquale, Larry Mann, RRT, Joseph Groller, RRT, Linda Cornman, RRT, Robert Leshko, RRT. Lehigh Valley Hospital. Allentown, PA, USA, 18105-1556.

Introduction: A 27 year old male, unrestrained driver was involved in a head-on motor vehicle accident, and required surgical repair of a torn right bronchus intermedius. Initially, the patient was ventilated using a 7200ae ventilator in the Pressure Control Ventilation (PCV) mode with eight cm H_2O of set PEEP. On post operative day two he developed a right bronchopleural fistula and a large left pulmonary contusion. By post operative day five, the right chest tube leak had increased and the chest x-ray demonstrated bilateral infiltrates. The patient's pulmonary status gradually worsened over the next few days, despite aggressive pulmonary hygiene and tracheostomy, and by post operative day nine he had developed left lung "white out", a C_{dyn} 15cc/cmH_20 and a P/F ratio 100. Attempts to utilize high inspiratory pressures and PEEP levels increased the right chest tube leak. **Method:** The decision was made to initiate Independent Lung Ventilation (ILV) utilizing a left Robertshaw double-lumen endotracheal tube and two 7200ae ventilators in the PCV mode. An attempt was made to synchronize the two ventilators by utilizing the same rate and a fixed inspiratory time, but this proved impractical and asynchronous ventilation was instituted. Two End-Tidal CO_2 monitors were used to follow alveolar ventilation and observe for signs of airway obstruction. The right lung was ventilated using low inspiratory pressures and set PEEP. The left lung was ventilated using high inspiratory pressures and set PEEP. **Results:** Within eight hours after the institution of ILV, the P/F ratio improved to 250, the C_{dyn} increased to 30cc/cmH_20, and the right chest tube leak decreased significantly. ILV was maintained for seven days. Subsequently, the patient was returned to conventional ventilation via a single-lumen tracheostomy tube and decannulated several days later.
In conclusion: Bronchopleural fistula can be successfully treated with Independent Lung Ventilation utilizing two asynchronous 7200ae ventilators in the PCV mode.

OF-99-047

HELIUM DELIVERY BY BIPAP® Sunisa Chatmongkolchart, MD, Purris Williams, BA, RRT, Ray Ritz, BA, RRT, Robert M Kacmarek, PhD, RRT, FAARC, Dean Hess, PhD, RRT, FAARC. Departments of Anesthesia and Critical Care, and Respiratory Care, Massachusetts General Hospital; Harvard Medical School; Boston, MA. Noninvasive positive pressure ventilation (NPPV) is used increasingly to avoid intubation during acute respiratory failure. Heliox is occasionally used for acute asthma. It has been speculated that NPPV with heliox may be useful in the management of acute asthma, and some clinicians have used this combination. We used a bench model to evaluate the delivery of heliox with BiPAP®. Method: A BiPAP® S/T-D30 ventilator (Respironics, Murrysville, PA) set to timed mode (30% inspiratory time) with plateau exhalation valve (Respironics, Murrysville, PA) was connected to a Michigan Instruments TTL® (Michigan Instruments, Inc. Grand Rapids, MI), compliance 0.05 L/cm H_2O. Inspiratory/expiratory pressure settings (cm H_2O) were 10/0, 10/5, 15/5, 20/5 and 20/10. Respiratory rates of 15/min and 30/min were used. A heliox mixture (80% helium/20% oxygen) was added either proximal (near the lung model) or distal (near the ventilator) at flows of 0, 5.4, 10.8, or 18 L/min using an oxygen flowmeter (Timeter Instrument Corp., St.Louis, MO) set at 0, 3, 6, or 10 L/min. Oxygen flows (Precision Medical, Inc. Northhampton, PA) of 0, 5, and 10 L/min were added in the proximal or distal position. After 10 minutes at each combination of settings, helium concentration in the lung model bellows was measured with a calibrated helium analyzer (PK Morgan LTD, Kent, England). Pressure in the lung model was measured with a calibrated pressure transducer (Validyne, Northridge, CA), digitized (Dataq Instruments, Inc. Akron, Ohio), and continuously recorded. Results: Delivered helium concentration was not affected by respiratory rate (P=0.46), proximal or distal heliox infusion (P=0.64), or oxygen infusion (P=0.94). Helium concentration in the lung model was significantly affected by helium flow (P<0.001) and BiPAP® setting (P=0.01). See Table for helium concentrations at the combinations of BiPAP® settings and heliox flows. There was no combination of settings in which the delivered helium concentration exceeded 60%. There was no significant effect of heliox on inspiratory pressure (P>0.5) or expiratory pressure (P>0.3). Conclusion: The addition of heliox to the BiPAP® circuit did not affect the function of the ventilator as reflected in the inspiratory and expiratory pressure settings. However, very high heliox flows (18 L/min) only resulted in delivery of helium concentrations approaching 60%. This suggests that use of BiPAP® for heliox therapy may be marginally effective. These results should be confirmed clinically.

BiPAP® setting	Heliox Flow (L/min)		
	5.4	10.8	18
20/5	0.12±0.02	0.24±0.04	0.40±0.06
20/10	0.14±0.02	0.29±0.04	0.48±0.07
15/5	0.15±0.02	0.28±0.03	0.46±0.08
10/0	0.17±0.04	0.31±0.02	0.50±0.06
10/5	0.22±0.10	0.37±0.09	0.52±0.05

OF-99-081

EVALUATION OF INSPIRATORY RISE TIMES IN NEW GENERATION MECHANICAL VENTILATORS Sunisa Chatmongkolchart, MD, Purris Williams, BA, RRT, Dean Hess, PhD, RRT, FAARC, Robert M Kacmarek, PhD, RRT, FAARC Anesthesia and Respiratory Care, Harvard Medical School and Massachusetts General Hospital, Boston, Massachusetts. Rise time during pressure targeted ventilation has been shown to be a factor affecting patient-ventilator synchrony. Both excessive and inadequate rise time may decrease patient-ventilator synchrony. Three different inspiratory rise times (minimum, medium, maximum) were evaluated in 5 new generation mechanical ventilators, (Hamilton Galileo, Siemens 300 A, Nellcor Puritan Bennett 840, Bear 1000, and Drager Evita) during both pressure support (PS) and pressure control (PC) in which PEEP was set at 5 cmH_2O and inspiratory pressure at 15 cmH_2O. All evaluations were performed on a spontaneous breathing lung model with compliance 50 ml/cmH_2O, airway resistance 8.2 cmH_2O/L/s, respiratory rate 12 breaths/min, inspiratory time 1.0 second, and peak inspiratory flow 60 L/min. There were some statistically significant differences (p<0.05) between PS and PC, but none were considered clinically important. Therefore we present only pressure support ventilation data (mean ± SD). Minimal differences exist between PS and PC during rise time adjustment. However, differences do exist among ventilators at similar rise time settings and with each ventilator as rise time is adjusted.

	PS	Galileo	Siemens	Pb840	Bear1000	Drager
P-T	minimum*	8.42 ± 0.10^{bc}	4.16 ± 0.10^{c}	4.59 ± 0.17^{bc}	—	6.61 ± 0.09^{bc}
	medium*	7.54 ± 0.00^{ac}	3.83 ± 0.20^{c}	3.77 ± 0.17^{ac}	4.78 ± 0.20	6.28 ± 0.09^{a}
	maximum*	5.69 ± 0.34^{ab}	1.91 ± 0.09^{ab}	1.86 ± 0.25^{ab}	4.43 ± 0.20	4.26 ± 0.00^{ab}
T-PTP	minimum*	0.92 ± 0.02^{bc}	0.45 ± 0.02^{bc}	0.34 ± 0.01^{bc}	—	0.90 ± 0.02^{bc}
	medium*	0.70 ± 0.01^{ac}	0.34 ± 0.02^{a}	0.23 ± 0.01^{ac}	0.38 ± 0.02^{c}	0.77 ± 0.02^{ac}
	maximum*	0.37 ± 0.02^{ab}	0.05 ± 0.00^{ab}	0.06 ± 0.01^{ab}	0.23 ± 0.01^{b}	0.14 ± 0.00^{ab}
Area I%	minimum*	0.53 ± 0.01^{b}	0.50 ± 0.01^{bc}	0.61 ± 0.01^{bc}	—	0.20 ± 0.00^{bc}
	medium*	0.62 ± 0.00^{a}	0.64 ± 0.00^{ac}	0.72 ± 0.00^{ac}	0.71 ± 0.00^{c}	0.35 ± 0.00^{ac}
	maximum*	0.77 ± 0.01^{ab}	0.79 ± 0.00^{ab}	0.87 ± 0.01^{ab}	0.77 ± 0.02^{b}	0.82 ± 0.01^{ab}

No data available for Bear 1000 at minimum setting. a = p<0.05 VS minimum for specific ventilator, b = p<0.05 VS medium for specific ventilator, c = p<0.05 VS maximum for specific ventilator, * = p<0.05 among ventilators. P-T-inspiratory trigger pressure; T-PTP-trigger pressure time product; Area I%-actual inspiratory area as a percentage of maximum possible inspiratory area.

OF-99-082

EVALUATION OF EXPIRATORY SENSITIVITY IN NEW GENERATION MECHANICAL VENTILATORS Sunisa Chatmongkolchart, MD, Purris Williams, BA, RRT, Dean Hess, PhD, RRT, FAARC, Robert M Kacmarek, PhD, RRT, FAARC Anesthesia and Respiratory Care, Harvard Medical School and Massachusetts General Hospital, Boston, Massachusetts. A lack of coordination between termination of patients' inspiratory efforts and the ventilators' inspiratory phase during pressure support (PS) can increase expiratory effort and ventilatory drive. We evaluated the performance of two new generation mechanical ventilators, (Hamilton Galileo and Nellcor Puritan Bennett 840) in 3 different expiratory sensitivity (minimum, medium, maximum) settings during pressure support (PS). Using a spontaneous breathing lung model set as follows: compliance 50 ml/cmH_2O, airway resistance 8.2 cmH_2O/L/s, respiratory rate 12 breaths/min, inspiratory time 1.0 second, and peak inspiratory flow 60 L/min. Throughout the evaluation pressure support was set at 15 cmH_2O with PEEP of 5 cmH_2O. Expiratory variables are shown below as mean ± SD. Differences exist between ventilators for all expiratory variables evaluated and for the individual ventilator at the three trigger settings. The minimum trigger setting resulted in the best transition to exhalation.

	PS	Galileo	Pb840
Area E	minimum*	11.98 ± 0.10^{bc}	-5.13 ± 0.31^{bc}
	medium*	12.86 ± 0.09^{ac}	6.48 ± 0.06^{a}
	maximum*	13.00 ± 0.05^{ab}	6.41 ± 0.33^{a}
P-E	minimum*	8.25 ± 0.09	0.00 ± 0.00^{bc}
	medium*	8.25 ± 0.19	3.22 ± 0.19^{a}
	maximum*	8.25 ± 0.09	3.44 ± 0.16^{a}
D-E	minimum*	0.17 ± 0.00^{bc}	0.00 ± 0.00^{bc}
	medium*	0.19 ± 0.01^{a}	0.07 ± 0.01^{a}
	maximum*	0.22 ± 0.01^{ab}	0.07 ± 0.00^{a}

a = p<0.05 VS minimum for specific ventilator, b = p<0.05 VS medium for specific ventilator, c = p<0.05 VS maximum for specific ventilator, * = p<0.05 among ventilators. Area-E-the area of sustained airway pressure during expiration; P-E-the pressure increase above set inspiratory pressure during the onset of exhalation; D-E-the time delay in airway pressure falling below set inspiratory level at the onset of expiration.

OF-99-083

PRESSURE SUPPORT (PS) AND PRESSURE ASSIST/CONTROL (PC) IN NEW GENERATION ICU VENTILATORS; Purris Williams, BS RRT, Matthew Muelver, Dean Hess, PhD RRT FAARC, Ray Ritz, BA RRT, Robert M. Kacmarek, PhD RRT FAARC. Departments of Anaesthesia and Critical Care and Respiratory Care, Massachusetts General Hospital and Harvard Medical School, Boston, MA. Current concerns regarding mechanical ventilator performance have focused on the response of the ventilator to patient demand. We used a spontaneously breathing lung model to evaluate the response of the following new generation ventilators to varying inspiratory demand in both PS and PC modes: Bear 1000 (Bear Medical Systems, Inc; Riverside, CA), Drager Evita 4 (Drager, Inc; Telford, PA), Hamilton Galileo (Hamilton Medical AG; Rhazuns, Switzerland), Intermed T-Bird (Bird Products Corp; Palm Springs, CA), Nellcor Puritan-Bennett 840 and 740 (Puritan-Bennett Corp; Pleasanton, CA), Siemens 300A (Siemens-Elema AB; Solna, Sweden). Methods: A bellow-in-a-box lung model was set at a respiratory rate of 12 breaths/min, inspiratory time of 1.0 second, and inspiratory flow rates of 40, 60 and 80 L/min. Each ventilator was set at three levels of PS and PC (10, 15 and 20 cm H_2O). On all ventilators flow triggering was set as sensitive as possible without causing self-cycling. When variable pressure rise time was available on a ventilator, the fastest setting was used. A pneumotachometer (Validyne; Northridge, CA) measured flow at the airway opening of the lung model and differential pressure transducers (Validyne) were used to measure pressures at the airway opening and in the simulated pleural space. A computerized graphics program (WINDAQ; Dataq Instruments Inc; Akron, OH) was used to digitize the signals and analyze the data. Results: Trigger pressure (P_T), trigger pressure-time product (T-PTP), inspiratory trigger time delay (D_T), inspiratory area as a per cent of the ideal inspiratory area (Area I%) and expiratory time delay (D_E) are listed below as mean±SD for all settings. Conclusions: There are differences between the responses of individual ventilators, but as a group these ventilators show an improved response to inspiratory demand in comparison to previous generations. For any given ventilator, there was little difference between PS and PC in terms of response of the ventilator to inspiratory demand.

PC	**Bear**	**Drager**	**Galileo**	**740**	**840**	**Siemens**	**TBird**
P_T (cmH_2O)	6.3±2.7	4.4±1.2	5.8±1.7	-	1.5±0.5	1.9±0.5	4.1±1.6
T-PTP	0.67±0.4	0.31±0.46	0.49±0.18	-	0.05±0.03	0.07±0.0	.27±0.18
D_T (msec)	90±20	70±10	100±10	-	60±10	50±10	80±10
Area I%	61.9±11.3	75.3±7.6	65.2±7.7	-	86.9±2.0	74.7±8.7	9.2±10.3
D_E	80±20	110±40	200±100	-	70±20	50±60	290±170
PS							
P_T (cmH_2O)	6.8±2.7	4.5±1.4	5.3±1.5	4.4±1.0	1.5±0.4	1.8±0.4	4.0±1.5
T-PTP	0.73±0.44	0.22±0.13	0.39±0.14	0.18±0.06	0.06±0.05	0.07±0.04	.29±0.23
D_T (msec)	90±10	60±10	90±10	70±10	50±5	50±10	80±10
Area I%	58.9±11.8	75.3±7.1	72.1±6.9	77.0±5.6	86.9±1.6	73.5±8.4	8.6±11.4
D_E	120±20	120±30	230±100	100±20	70±10	170±70	340±180

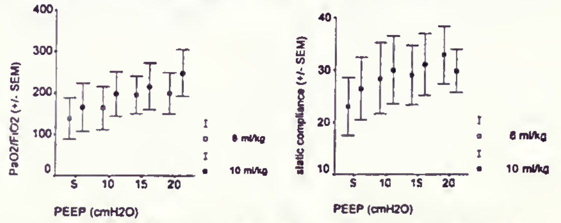
OF-99-101

THE SHORT TERM EFFECT OF PEEP LEVELS AND TIDAL VOLUMES ON OXYGENATION AND PULMONARY MECHANICS IN ALI/ARDS PATIENTS. Darren Burns, R.R.T., G. O'Keefe, M.D., Parkland Health & Hospital System, 5201 Harry Hines Blvd., Dallas, Texas 75235

BACKGROUND: Smaller tidal volumes have been suggested to minimize ventilator associated lung injury in patients with ARDS. The acute effects of such an approach upon measures of gas exchange and lung mechanics is not certain in humans. Moreover, the interaction of differing tidal volumes and levels of PEEP are also unclear, primarily due to the variability between patients and over time in patients with ALI. In this study, we sought to measure the affects of different tidal volume-PEEP combinations upon oxygenation and C_{st} and we hypothesized that PaO_2 would continue to improve after C_{st} had been maximized.

METHODS: Based upon a PaO_2/FIO_2 of <250, bilateral infiltrates on CXR, and PCWP <18, five patients were enrolled. PEEP (5,10,15 or 20 cmH_2O) and tidal volume (6 or 10 ml/kg) combinations were applied in random order and measurements (PaO_2, Vd/Vt, C_{st}) made at each setting after a 5-minute stabilization period. FiO_2 was held constant (80-90%) throughout the experiments. Upon completion, the patient was returned to previous ventilator settings. Statistical comparisons were made between the tidal volume settings at each PEEP level using the Wilcoxon Signed Rank test and ANOVA was used to compare C_{st}, and P/F ratio across increasing PEEP levels.

RESULTS: The P/F ratio was slightly higher at 10ml/kg compared to 6ml/kg tidal volumes at each level of PEEP. C_{st} was significantly higher with 10 ml/kg with PEEP = 5 cmH_2O (p = 0.03). Only at the highest PEEP level was C_{st} better with 6ml/kg tidal volume (p = 0.14). The trends of increasing C_{st} and P/F ratio with increasing PEEP were not statistically significant.



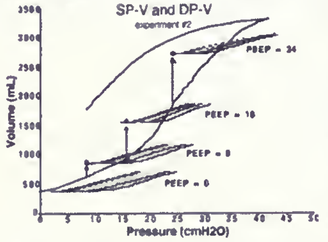
CONCLUSIONS: Our data suggest that the potential lung protective benefits associated with small tidal volumes may only be realized at higher levels of PEEP. The clinical implications of this is of considerable importance given the trend towards lower tidal volume ventilation in patients with ALI/ARDS. In keeping with our hypothesis, maximizing oxygenation may result at a cost to pulmonary mechanics that may in turn result in lung injury and increased time on the ventilator. These results must be cautiously interpreted because of the small sample size reported here.

OF-99-143

STATIC PRESSURE-VOLUME CURVES DO NOT FULLY REFLECT RECRUITMENT DURING TIDAL VENTILATION. Alexander Adams RRT, Nahit Cakar MD, Avi Nahum MD, PhD, John Marini MD. Regions Hospital, University of Minnesota, St. Paul, MN.

Introduction: Static inspiratory pressure volume (SP-V) curves of the respiratory system have been advocated to guide ventilator settings (PEEP and tidal volume) with the goal of optimizing stable recruitment. It is generally well known the DP-V curves are shifted rightward by an amount dependent on auto-PEEP and flow resistive pressure. It is less generally understood that recruitment may occur as a function of VT and PEEP. Because increasing tidal volume may aid recruitment, the relevance of SP-V curves to the dynamic condition of tidal ventilation remains obscure. Our objective was to compare the pressure-volume relationships under static and dynamic conditions. We compared functional residual capacity (FRC) under dynamic conditions to the volume from the corresponding SP-V curve under a range of ventilatory conditions in an oleic acid lung injury model.

Methods: Five mongrel dogs were anesthetized, paralyzed and monitored to assure a stable preparation. Acute lung injury was induced by oleic acid infusion and the injury was well established after 4 hours of ventilation. FRC at ZEEP was measured by helium dilution and flow and pressure by standard methods. By dropping PEEP to ZEEP for 20 seconds we measured end expiratory lung volume change (ΔEELV) by continuously monitoring the corresponding lung volume decrease by respiratory inductance plethysmography. Total FRC at a specific PEEP level = (FRC at ZEEP) + ΔEELV. SP-V curves were constructed by the super syringe method. DP-V curves were recorded for the conditions PEEP = 0, 8, 16 and 24 cmH2O, flow=10, 20, 30, 40, 50 L/min. without changing frequency or tidal volume (f=15/min, VT=350 ml.). **Results:** Mean total FRC was increased above the SP-V FRC by 267±86, 425±129, 494±199 ml for PEEP = 8, 16, 24 cmH2O (arrows on representative figure). Increasing the flow setting shifted DP-V curves rightward. **Conclusions:**. We conclude that substantial recruitment occurs under dynamic conditions that is not reflected by the classical SP-V curve and that the contours of the SP-V curve may not necessarily reflect the events of tidal ventilation. Dynamic P-V curves are shifted rightward in proportion to flow and autoPEEP detracting from their clinical utility.



OF-99-164

THE CPAP PRESSURE NEEDS OF OBSTRUCTIVE SLEEP APNEA PATIENTS VARY FROM NIGHT TO NIGHT

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Purpose: To study the degree of variability in upper airway resistance in Obstructive Sleep Apnea (OSA) patients.

Background: The use of automatically adjusting CPAP devices to treat patients diagnosed with OSA presented an opportunity to study the variation of OSA since the pressure usage profiles obtained from these devices are derived from individual patient fluctuations in upper airway resistance. The device is capable of storing over a month worth of data; such as, mean CPAP pressure used ($CPAP_{mean}$) and 90th percentile CPAP pressure ($CPAP_{max}$).

Method: We examined the first full week of CPAP pressure utilization data in 12 OSA patients. Attention was focused on the $CPAP_{mean}$ and $CPAP_{max}$ as indicators of each nightfs pressure need. The standard deviation of these numbers was calculated for each individual patient as well as for the entire group. For each individual patient, the week's highest mean pressure ($CPAP_{mean\ max}$), lowest mean pressure ($CPAP_{mean\ min}$), and the difference between the two ($CPAP_{mean\ diff}$) was noted. The same was done for $CPAP_{max}$ so as to calculate the greatest difference in the $CPAP_{max}$ during the course of a week ($CPAP_{max\ diff}$).

Results: The $CPAP_{mean}$ for the 12 patients studied was 6.9 cm H_2O. The $CPAP_{max}$ was 8.5 cm H_2O. The standard deviation of $CPAP_{mean}$ was .62. The standard deviation for $CPAP_{max}$ was .80. $CPAP_{mean\ diff}$ was 1.8 cm H_2O for the entire group and was noted to be > 1 cm H_2O in 9/12 (75%) and greater than 2 cm in 3/12 (25%) of OSA patients. $CPAP_{max\ diff}$ was 2.2 cm H_2O for the entire group and was found to be > 1 cm H_2O in 10/12 (83%) and > 2 cm H_2O in 6/12 (50%) of the 12 patients studied.

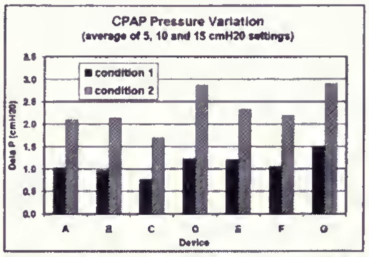
Conclusions: Both the mean and maximal CPAP pressure needs of OSA patients vary on a night to night basis. One centimeter differences in these pressures should be expected. Two centimeter differences in these pressures are surprisingly frequent. This data should raise concern regarding the adequacy of any CPAP pressure data derived from a one night sample period to predict the ongoing pressure needs of an OSA patient over multiple nights.

OF-99-169

COMPARISON OF PRESSURE VARIATION IN NASAL CPAP SYSTEMS.

Bliss PL, McCoy RW. Regions Hospital, St. Paul, MN.

Introduction: Several devices are commercially available to provide nasal CPAP for the treatment of obstructive sleep apnea. All are based on centrifugal blowers with an internal method of pressure control. Ideally, airway pressure would be exactly constant throughout breathing, regardless of flow. In practice, pressure actually decreases slightly during inhalation and increases during exhalation, due to the mechanics of the blower. Previous studies have shown a high rate of non-compliance among CPAP users. The ability to maintain CPAP pressure may have an effect on patient work of breathing and hence, patient compliance. We compared the pressure regulation of seven commercially available CPAP systems under a variety of settings and breathing patterns, using a mechanical test lung model. **Methods:** One side of a mechanical test lung (Michigan Instruments 1600), was driven by a linked ventilator (Puritan Bennett 7200ae). The second, "breathing" side of the lung was connected via a 6 foot, 22 mmID patient tube to each CPAP system. An intentional leak (4 mm dia.), pressure transducer and pneumotachometer were interposed in the breathing limb, proximal to the lung. Two breathing patterns were simulated, condition 1 F=12/min, VT=500mL, Peak Inspiratory Flow (PIF)=28L/min and condition 2, F=12/min, VT=800mL, PIF=41L/min. A computer data acquisition system was used to monitor pressure and flow. The difference between the maximum and minimum pressures delivered by each device during the two breathing conditions was evaluated at CPAP settings of 5, 10 and 15 cmH2O.



Results: For condition 1, the mean (± S.D.) pressure range for all devices at all settings was 1.12 (±0.25) cmH20. For condition 2, it was 2.32 (±0.43). Changing CPAP settings had a small effect on the pressure range (The mean intra-device variance was 0.22 and 0.43 cmH2O for the two conditions). There was a large inter-device variance (see figure). **Conclusions:** There is variance in the ability to maintain pressure between CPAP devices, which increases with increasing VT and Peak Flow. This may have an adverse affect on patient work of breathing and ultimately, patient compliance.

OF-99-179

EVALUATION OF A NEW SELF-TITRATING CPAP DEVICE. Robert Ballard, Karrie Sanders, William Hardy, Todd Dextradeur, Zoe Pouliot, Meir Kryger. Sleep Health Centers at National Jewish, Denver, CO, and St. Boniface General Hospital Research Center, Winnipeg, Canada.

A newly available self-titrating CPAP (continuous positive airway pressure) device (Tranquility Auto, Respironics, Inc.) titrates to therapeutic pressure by analyzing airflow patterns at different pressures for evidence of airflow limitation. To assess the accuracy of this technique and device, we performed sleep studies on 28 patients with confirmed obstructive sleep apnea (mean AHI = 55.3 ± 6.7), comparing sleep and respiratory patterns while treated with a manually titrated level of CPAP (night 1) or self-titrated CPAP using the Tranquility Auto (night 2). The mean CPAP generated by manual titration was 10.5 ± 2.8 cm H_2O, while that generated by the Tranquility Auto was 10.6 ± 2.1 cm H_2O (NS). The table demonstrates the respective effects upon total sleep time (TST), apnea-hypopnea index (AHI), arousal index (ARI), minimum O_2 saturation (SaO_2 min), and % TST below an SaO_2 of 90% (% < 90%).

	TST	AHI	ARI	SaO_2 min	% < 90%
Manual	332	6.2	15.1	83.4	8.4
(SD)	(67)	(7.7)	(10.2)	(8.5)	(14.3)
Tranquility Auto	325	6.5	16.6	86.4	4.8
(SD)	(78)	(8.5)	(12.5)	(3.5)	(8.4)

None of these measures differed significantly between the manually titrated pressure and the Tranquility Auto. We found that the Tranquility Auto yielded CPAP levels that were similar to and as effective as manual CPAP titration. We conclude that this new self-titrating device will be useful for both determining appropriate levels of fixed CPAP and possibly for the ongoing home administration of CPAP therapy.

OF-99-198

SUCCESSFUL USE OF NEW MICROPROCESSOR HOME VENTILATOR, THE T BIRD LEGACY, TO DELIVER HIGH CONSISTENT PEEP IN THE PRESENCE OF A LARGE LEAK AROUND A TRACHEOSTOMY TUBE:

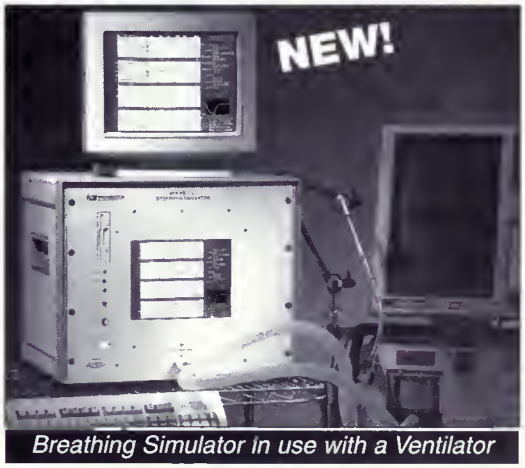
A Case Study: Katie Sabato MS RRT, Vivian Newman, MD Children's Hospital Oakland, Ca.

Introduction This is a 8-year-old ventilator dependent, quadriplegic, child with severe bronchopulmonary dysplasia, and achondroplasia (dwarfism) who despite such handicaps is a delightful cognitive appropriate for age and able to effectively vocalize via a leak around his tracheotomy tube; who without the support of the new T BIRD LEGACY home ventilator would need to remain in an Intensive Care Unit

Case summery: The patient was admitted to our PICU for recurrent atelectasis and severe pneumonia. He was removed from his home ventilator and stabilized on our hospital VIP BIRD ventilator utilizing volume ventilation and a PEEP of 8. All attempts to lower the PEEP resulted in progressive atelectasis. The unique leak compensation function available in the VIP BIRD ventilator permitted consistent effective delivery of PEEP despite a leak around the patient's tracheotomy of 20 - 45 percent. Three attempts over a 2-week period to return him to his traditional home ventilator failed despite the addition of continuous flow and an external PEEP valve set to deliver 8 cm of PEEP. All three weaning attempts resulted in the patient becoming febrile within 48 hours, developing migrating atelectasis with worsening ventilation and oxygenation status. The traditional home ventilator with its external PEEP value was unable to maintain sufficient consistent effective PEEP in the presence of a variable leak. This left us with two options: 1) The patient would need to remain in our PICU on a sophisticated leak compensated ventilator, 2) Succumb to placement of a larger or cuffed tracheotomy tube that would eliminate his ability to verbally communicate. Fortunately, during this time a new generation microprocessor home ventilator the T BIRD LEGACY became available. The T BIRD LEGACY is a microprocessor home ventilator which via a fixed pitched turbine and a bias flow function is able to control and maintain consistent PEEP in the presence of variable and significant leaks around tracheotomy tubes. The patient made a smooth transition to the T BIRD LEGACY and was discharged to home on volume ventilation with 8 cm PEEP. Five months latter he remains stable and has return to school

Conclusion: Application of theT BIRD LEGACY provided this patient with advanced lung disease the opportunity to remain safely and effectively ventilated in the home environment. The T BIRD LEGACY home ventilator has additional modes and functions that may offer other hospital bound ventilator - dependent patients the opportunity to make a safe, efficient, and effective, transition to the home environment. Further evaluation of the T BIRD LEGACY is needed.

OF-99-192



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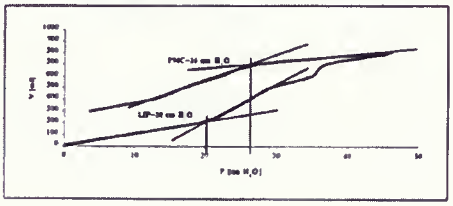
THE RELATIONSHIP BETWEEN OPTIMAL MEAN AIRWAY PRESSURE IN HIGH FREQUENCY OSCILLATORY VENTILATION (HFOV) AND THE STATIC PRESSURE VOLUME CURVE IN AN OVINE MODEL OF ADULT ARDS

Sven Goddon, MD, Yuji Fujino, MD, Jonathan Hromi, BA; Robert Kacmarek, PhO, RRT. Anaesthesia and Respiratory Care, Massachusetts General Hospital and Harvard Medical School, Boston, MA.

Current guidelines for conventional mechanical ventilation in adults recommend setting the PEEP at 2 cm H_2O above the lower inflection point (LIP) of the inspiratory P-V curve. In HFOV currently no equivalent recommendation for the setting of the mean airway pressure ($P\overline{AW}$) exists. We hypothesized that the $P\overline{AW}$ resulting in the best oxygenation (optimal $P\overline{AW}$) can be related to and thus predicted from the static P-V curve of the respiratory system in a large animal model of ARDS. **Methods:** In seven sheep (28±5 kg) severe lung injury was induced by repeated saline lung lavages until P/F-ratio decreased to 85±27 at PEEP 5 cm H_2O. The LIP (20±0.7 cm H_2O) on the inspiratory limb and the point of maximal curvature (PMC, 26±0.9 cm H_2O) on the expiratory limb of the static P-V curve were determined by a blinded investigator. The sheep were then subjected to four one-hour cycles of HFOV (f 8 Hz, FiO_2 1.0) at different levels of $P\overline{AW}$ (LIP+2, LIP+6, LIP+10, LIP+14 cm H_2O), applied in random order. Each cycle was preceded by a standardized de-recruitment (30 s ventilator disconnection) followed by a sustained insufflation (recruitment manoeuvre) with a $P\overline{AW}$ of 50 cm H_2O for 60 s. **Results:** HFOV with a $P\overline{AW}$ of 6 cm H_2O above LIP resulted in a highly significant improvement of oxygenation (333±176 torr, $p<0.01$ vs. Injury) and venous admixture (0.26±0.12, $p<0.05$ vs. Injury). LIP+6 significantly correlated with the PMC ($r=0.77$, $p<0.05$). Whereas no further improvement in oxygenation or venous admixture could be seen with higher $P\overline{AW}$. Cardiac output and oxygen delivery were significantly impaired at $P\overline{AW}$ settings higher than LIP+6. **Conclusion:** The optimal $P\overline{AW}$ (least pressure with highest PaO_2) in HFOV can be predicted from the static P-V curve. It correlates with the PMC on the expiratory limb of the P-V curve.

Fig.: Representative P-V curve in a lung-injured sheep, obtained with a super syringe.

LIP=lower inflection point, PMC=point of maximal curvature



OF-99-215

OPTIMAL MEAN AIRWAY PRESSURE FOR HIGH-FREQUENCY-OSCILLATORY-PARTIAL-LIQUID-VENTILATION IN AN OVINE MODEL OF ADULT ARDS

Sven Goddon, MD; Muneyuki Takeuchi, MD; Jonathan Hromi, BA; Robert Kacmarek, PhD, RRT. Anaesthesia and Respiratory Care Laboratories, Massachusetts General Hospital and Harvard Medical School, Boston, MA.

Previous preclinical investigations on the effects of High-Frequency-Oscillatory-Partial-Liquid-Ventilation (HFO-PLV) on pulmonary gas-exchange have yielded varied results One reason for that being that the mean airway pressure ($P\overline{AW}$) was always set arbitrarily. We therefore investigated four different settings for $P\overline{AW}$, based on the results of the static P-V curve of the respiratory system. We hypothesized that the $P\overline{AW}$ resulting in the best oxygenation (optimal $P\overline{AW}$) can be related to and thus predicted from the static P-V curve of the respiratory system in a large animal model of ARDS. **Methods:** In six sheep (31±5 kg) severe lung injury was induced by repeated saline lung lavages until PaO_2 decreased to less than 120 torr at volume controlled ventilation (FiO_2 1.0, V_t 12 ml/kg, PEEP 5 cm H_2O). The lower inflection point (LIP. 20±0.8 cm H_2O) on the inspiratory limb and the point of maximal curvature (PMC, 26±0.8 cm H_2O) on the expiratory limb of the static P-V curve were determined by a blinded investigator. 10 ml/kg perflubron (PFB) were slowly instilled through a sideport of the endotracheal tube during volume controlled ventilation with the PEEP increased to 13 cm H_2O. 30 min after the PFB instillation another P-V curve was obtained. The sheep were then subjected to four half-hour cycles of HFOV (f 4 Hz, amplitude 40 cm H_2O) at different levels of $P\overline{AW}$ (PMC-8, PMC-4, PMC, PMC+4 cm H_2O), applied in random order (FiO_2 1.0). The first cycle was preceded by a sustained insufflation (recruitment manoeuvre) with a CPAP of 40 cm H_2O for 60 s. **Results:** HFO-PLV with a $P\overline{AW}$ equal to the PMC resulted in a highly significant ($p<0.01$ vs. Injury) improvement of oxygenation and venous admixture (Q_S/Q_T). A higher $P\overline{AW}$ did not yield further improvement in PaO_2 or Q_S/Q_T but significantly impaired cardiac output (CO) and oxygen delivery (DaO_2).

	Injury	Postfill	PMC-8	PMC-4	PMC	PMC+4
PaO_2	72±21	256±107	132±99	263±103†	445±102$^{\dagger\ddagger *}$	430±107$^{\dagger\ddagger *}$
CO	5.1±0.8	4.6±1.0	5.1±0.8	4.8±0.4	4.6±0.3	3.1±0.7$^{\dagger\ddagger * \circ}$
DaO_2	551±93	577±142	606±143	591±109	589±77	394±93$^{\dagger\ddagger * \circ}$
Q_S/Q_T	0.35±0.04	0.27±0.07	0.35±0.08	0.25±0.03	0.15±0.05†‡	0.15±0.08†‡
OI	18±7	9±5	20±11	10±5	6±2†‡	7±2‡

Table 1 mean±SD $P<0.05$. † vs. Injury, ‡ vs. PMC-8, * vs. PMC-4, o vs. PMC

Conclusion: In this ovine model of adult ARDS the optimal $P\overline{AW}$ (least pressure with highest PaO_2) in HFO-PLV can be predicted from the static P-V curve. It coincides approximately with the PMC on the expiratory limb of the P-V curve.

This study was funded by Alliance Pharmaceutical Corp., San Diego, CA

OF-99-216

EFFECT OF FREQUENCY ON GAS EXCHANGE DURING HFO-PLV IN ARDS SHEEP MODEL

Muneyuki Takeuchi, MD, Sven Goddon, MD, Jonathan Hromi, BA, Robert M Kacmarek, PhD, RRT. Anaesthesia and Respiratory Care, Massachusetts General Hospital and Harvard Medical School, Boston, MA

Both partial liquid ventilation™ (PLV) and high frequency oscillatory ventilation (HFOV) have been used to recruit lung in ARDS. The combination of PLV and HFOV would seem ideal, achieving alveolar recruitment with perflubron in the severely injured dorsal lung and protection of the less injured ventral lung by avoiding significant pressure and volume excursions. Pilot data revealed that high frequency oscillatory partial liquid ventilation (HFO-PLV) was most effective when mean airway pressure was set at the point of maximum curvature on the deflation limb of the quasi-static respiratory system PV curve. But no study evaluating the effects of frequency on gas exchange during HFO-PLV in large lungs is available. The aim of this study was to determine the effects of frequency on oxygenation as well as ventilation.

METHODS: Five anesthetized sheep (25 to 35 kg) instrumented for hemodynamics and blood collection received lung injury by repeated lung lavage with warmed saline until PaO_2/F_IO_2 ratio fell below 120 (VCV, PEEP 5 cm H_2O, TV 12 mL/kg). After injury was established, all the sheep were filled with 10 mL/kg perflubron (LiquiVent®, Alliance Pharmaceutical Corp.) (VCV, PEEP 13 cmH_2O, TV 12 mL/kg) and then were ventilated with HFOV (mean airway pressure 26 cmH_2O, pressure amplitude 40 cmH_2O, I:E ratio 1:1) after a recruitment maneuver (CPAP of 40 cmH_2O for 1 min). Frequencies of 4, 6, 8 and 10 Hz were randomly applied for 30 min. The change in airway pressure across the endotracheal tube was also monitored.

RESULTS: HFO-PLV improved gas exchange. However as frequency increased above 4 Hz, PaO_2 decreased and $PaCO_2$ increased. No hemodynamic differences at any frequency were observed.

	injury	post-fill VCV	4 Hz	6 Hz	8 Hz	10 Hz
PaO_2 ' (F_IO_2 1.0)	81 ± 19*	240 ± 41*	480 ± 32	393 ± 49*	316 = 102*	251 ± 123*
$PaCO_2$ '	45 ± 5	44 = 6	35 ± 6	41± 8	47 = 13	58 ± 16*
$AaDO_2$ '	587 ± 21*	429 ± 38*	198 ± 29	279 ± 51	349 = 108	405 ± 117*
OI	15 ± 5	8 ± 1	5 ± 0	7 ± 1	10 = 5	17 ± 18
trac press amp	-	-	11 ± 4	11± 5	13 = 6	13± 4

' units, mmHg

Mean ± SD

trac press amp: pressure swing (cmH_2O) measured in the trachea.

*$p < 0.05$ vs. 4 Hz

CONCLUSION: HFO-PLV improvements in gas exchange are markedly affected by frequency. Optimal CO_2 elimination and oxygenation occurred at 4 Hz in this study.

This study was funded by Alliance Pharmaceutical Corp., San Diego, CA.

OF-99-217

PERFORMANCE CHARACTERISICS DURING CPAP IN NEW GENERATION MECHANICAL VENTILATORS

Takeuchi M, Williams P, Muelver, M, Fujino Y, Goddon S, Kratohvil J, Ritz R, Hess D, Kacmarek RM.
Anaesthesia and Respiratory Care, Massachusetts General Hospital and Harvard Medical School, Boston, MA

Many studies have evaluated the performance characteristics of ventilators during assisted ventilation. However, little information on performance during CPAP is available. We questioned if the currently available ventilators were responsive to inspiratory efforts and capable of meeting peak inspiratory flow demands without imposing an expiratory load. We evaluated the performance of seven new generation ventilators during CPAP.

METHODS: The Bear 1000, Drager Evita 4, Hamilton Galileo, Nellcor Puritan-Bennett 740 and 840, Siemens 300A and Intermed T-Bird were evaluated, using a lung model with three peak inspiratory flows (40, 60 and 80 L/min) during CPAP of 10 cmH_2O. The effects of flow trigger (F) and pressure trigger (P) were compared in 4 of these ventilators that have both triggering systems. Triggering was set as sensitive as possible without causing autocycling. Time (trigger delay, sec) and pressure (trigger pressure, cmH_2O) to trigger the ventilator, airway pressure time product during inspiration (insp. area, cmH_2O*sec), pressure difference between minimum airway pressure and maximum pressure (press. swing, cmH_2O) and airway pressure time product during expiration (exp. area, cmH_2O*sec) were calculated.

RESULTS:

		Bear	Drager	Galileo	PB740	PB840	S300	T-Bird
trigger delay	F	0.11±0.01*	0.10±0.01*	0.11±0.01*	0.07±0.00	0.06±0.01	0.06±0.02	0.09±0.01
	P	0.09±0.01	-	0.12±0.01*	-	0.06±0.00	0.07±0.00	-
trigger pressure	F	4.6±1.2*	4.5±1.4	5.8±1.7*	3.9±0.7	2.3±0.8	2.3±0.7	3.2±0.7
	P	5.5±1.4*	-	5.9±1.7*	-	3.1±0.6	3.4±0.4	-
insp area	F	-1.0±0.1*	-0.8±0.6*	1.7±0.7	1.2±0.8	1.1±0.3	0.8±0.6	0.4±0.3
	P	-0.3±0.3*	-	1.6±0.8	-	1.2±0.2	0.8±0.6	-
press swing	F	11.0±3.9	9.8±2.5	19.2±4.3*	11.6±1.9	8.0±1.6	12.5±2.6	12.3±3.0
	P	15.0±5.9*	-	19.2±4.3*	-	9.0±1.5	13.6±2.4	-
exp area	F	1.6±0.6	1.8±0.7	8.0±0.7*	1.9±0.8	3.3±0.8	2.5±1.7	6.8±1.7*
	P	3.6±1.0*	-	8.1±1.0*	-	3.3±1.1	2.4±1.9	-

mean ± SD

*$p < 0.05$ vs PB840 flow trigger, *$p < 0.05$ pressure vs. flow trigger. (ANOVA followed by Scheffe test)

CONCLUSION: There was a large range of variability in performance characteristics during CPAP among new generation mechanical ventilators. In addition, in the Bear ventilator there were large differences between flow and pressure triggers.

OF-99-218

MEDICATION COST SAVINGS UTILIZING DRÄGER EVITA4 & DURA2 VENTILATORS

Lori Hand, B.Sc., R.R.T., C.H.T.; Lisa O'Drowsky, B.Sc., R.R.T.
Hamilton Health Sciences Corporation, Hamilton, Ontario, Canada

BACKGROUND: Positive pressure mechanical ventilation with deep sedation and/or muscle paralysis often results in reduced, even elimination of, diaphragmatic motility. Alveoli become hypoventilated in regions near the diaphragm leading to ventilation perfusion (V/Q) mismatch in the lung. The goal of technologically advanced mechanical ventilators is to restore or maintain spontaneous breathing despite poor gas exchange in hopes of alleviating V/Q mismatch. Analgesia, not sedation or paralysis should be the goal in managing mechanically ventilated patients. With decreased utilization of sedative and/or paralytic agents, costs are directly reduced in medication use, potentially decreased ventilator hours and fewer intensive care patient days. Unlike traditional mechanical ventilators, the *Drager* Evita4 and Dura2 ventilators possess a "floating" exhalation valve which does not wholly occlude the expiratory limb outlet during any phase of the respiratory cycle. This allows the patient to cough or initiate spontaneous breathing at any point within the mechanical cycle, leading to increased patient comfort (decreased ventilator asynchrony) with a concomitant reduction in sedatives and paralytics. Purpose: To identify if the *Drager* Evita4 and Dura2 ventilators, with advanced technology of the "floating" exhalation valve, lead to a decrease in sedation and/or paralytic requirements, compared to conventional mechanical ventilators, and; to determine daily cost savings per case in sedation and paralytics, of *Drager* Evita4 and Dura2 mechanically ventilated patients. **METHOD:** A retrospective chart review of one patient included review of bedside flowsheets and medication profiles. All intravenous and bolus administrations of lorazepam (Ativan®) and vecuronium (Norcuron®) were respectively totaled for the period the patient was ventilated with a mechanical ventilator not possessing a "floating" exhalation valve. In consultation with the clinical pharmacist, costs for each medication were calculated for a 24 hour period. **RESULTS** and **EXPERIENCE:** An estimated total cost savings of $100.00 (Canadian) in sedation and paralytic over a 24 hour period was revealed. This was identified when the *Drager* Evita4 was changed to an alternate brand of ventilator on a patient who previously did not require sedation and paralysis. Once placed on like parameters on the alternate ventilator, sedation and paralysis were necessitated within thirty minutes to effectively ventilate the patient. When the patient was placed back on the *Drager* Evita4, both the sedative and paralytic were discontinued over an 18 hour period. **CONCLUSIONS:** Due to the advanced technology of the "floating" exhalation valve in the *Drager* Evita4 and Dura2 ventilators, less sedation and/or paralytics are required to comfortably and effectively mechanically ventilate patients. This reduction in medication requirements may result in cost savings seen in medication utilization and, potential fewer ventilator and intensive care patient days. The anticipated medication cost savings over a 12 month period would offset the majority of capital purchase costs of the *Drager* Evita4 and Dura2 ventilators. This finding prompts further review of medication requirements in patients ventilated with *Drager* Evita4 and Dura2 ventilators.

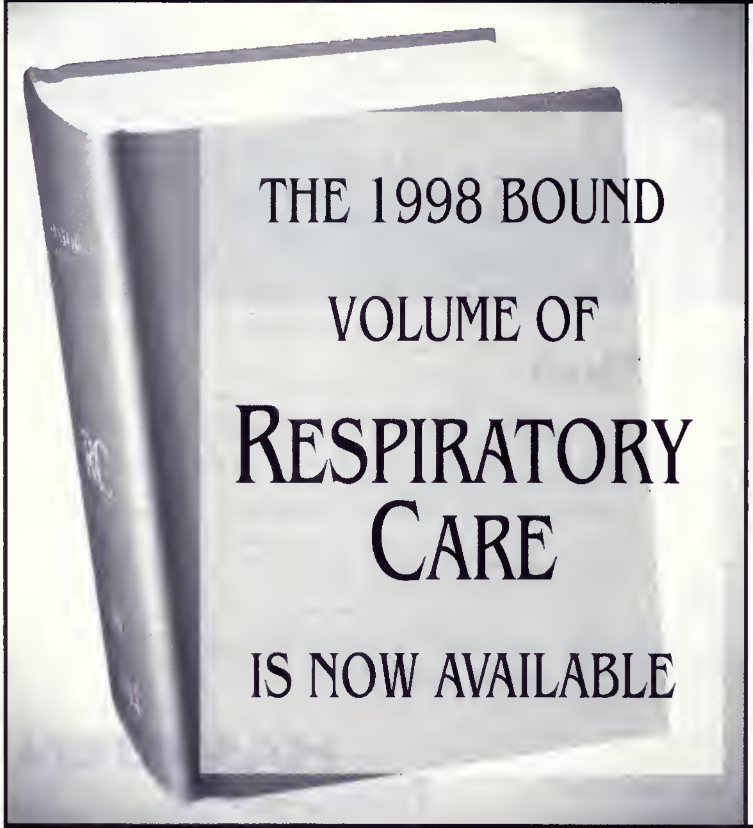
OF-99-235

TREATMENT OF 38 PATIENTS WITH TYPE II RESPIRATORY FAILURE BY MECHANICAL VENTILATION

Xia Xirong & Shi Yi. Jinling Hospital, Respiratory Department, Nanjing, Jiangsu Province P. R. China.

BACKGROUND: This paper reported clinical experience of 38 patients (45 times) type II respiratory failure whom we treated with mechanical ventilation (MV) between 1983 to 1998. Coma and severe carbon dioxide retention were the main indications. METHOD: The artificial airway types includes tracheostomy (15), through oral intubation (8) through fiber bronchoscopy intubation (6) and intubation plus tracheostomy (16). The duration of intubation was 13.12°± 4.31(7-21days). We used Servo 900c respirators (Siemens) to treat this group of patients. Intermittent mechanical ventilation (IMV) and pressure support ventilation (PSV) were advantages for weaning from the respirator. No patient in this group became dependent on the respirator. RESULTS: The main complications of MV included hypotension (48.89%), arrhythmia (20.3%), gastrointestinal haemorrhage (7.8%), and thoracic barotrauma (5.5%). The rate of success of this therapy was 71.11% (25 cases). The survival time for one year was 67.1%; 5-year survival was 23.51%, with only two patients surviving more than 10 years.
CONCLUSION: MV is an effective method for treating Type II respiratory failure.

OF-99-240



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MEASURING HEALTH STATUS OUTCOMES PRE AND POST PULMONARY REHABILITATION.

Theodora M. Focht, LRT, RRT, RPFT, Charleston Area Medical Center, 3200 MacCorkle Ave, S. E., Charleston, WV 25304

BACKGROUND: The Pulmonary Rehabilitation Program utilizes a Health Status Questionnaire (HSQ) pre and post program as an outcome measurement tool. The HSQ is composed of 36 questions, assessing eight specific health attributes, grouped under three major health dimensions: overall evaluation of health (health perception), functional status (physical and social functioning, role limitations attributed to physical health, and emotional perception), and well-being (bodily and mental pain, energy/fatigue). METHOD: The questionnaire is administered on orientation day and 8 weeks later on graduation day. Graduation day the participants do not see the questionnaire that was completed on orientation. Questionnaires that were not completed by a participant pre and post program were discarded from this review. HSQ scoring is designed to represent positive attributes perceived by the patient, the highest percent indicating an improvement. Pre and Post negative inspiratory force maneuvers (NIF) were completed on each participate to identify improvement in inspiratory muscle strength after reconditioning. RESULTS: There were 9 classes reviewed for 1998. A total of 41 participants completed both pre and post questionnaires. The average was taken for each of the health attribute categories pre and post program. The percent change was then calculated. The following HSQ information was obtained:

	Pre	Post	% Improvement
Health Perception	45%,	49%	4%
Physical Functioning	28%	39%	11%
Role Limitations (Physical)	19%	40%	21%
Role Limitations (Emotional)	51%	54%	3%
Social Functioning	57%	70%	13%
Mental Health	70%	73%	3%
Free From Bodily Pain	64%	67%	3%
Energy/Fatigue	39%	51%	12%
NIF Maneuver	-54	-65	20%

CONCLUSION: The HSQ demonstrates the Pulmonary Rehabilitation Program shows improvement in a participant's quality of life and increases muscle strength and endurance.

OF-99-005

THE EFFECT OF WATER IMMERSION ON SUBJECTS WITH COPD DURING PEAK LOWER EXTREMITY EXERCISE ON TREADMILL

Mark Millard, MD; Mary Hart, RRT; Ana Lotshaw, PT, CCS; Cara Kraft, RRT
Baylor University Medical Center, Dallas, Texas, USA

We compared maximal treadmill exercise tolerance (water vs. land) in 7 patients with COPD (FEV1 <60% predicted). Treadmill tests were performed on 3 stage intervals with 1 minute rest between stages. Vitals, oxygen saturation, BORG, VO2 and VE were measured at each stage and at peak exercise. At peak level of treadmill exercise, there were no significant differences in VO2, vital signs, O2 saturation, VE, or BORG (RPE) between land and water lower extremity treadmill exercise. However, all of the subjects preferred water exercise to land exercise. None of the subjects experienced dangerous changes in the vital signs or oxygen saturation during testing. Aquatic exercise may be very beneficial for those with COPD and musculoskeletal limitations that make performing exercise on land more difficult and may be an alternative mode of exercise training in a variety of patient populations, including those with pulmonary limitations.

	AVERAGE MAXIMUM			
	VO2	VE	HR	BORG
LAND	11.2 ml/ kg / min	29.8 lpm	129 bpm	15.5
WATER	11.8 ml/ kg / min	30.2 lpm	122 bpm	14.8

Baylor University Medical Center

OF-99-062

LUNG FUNCTION REFERENCE VALUES: 10 YEARS FOLLOW-UP

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Standardized lung function measurements were carried out in 680 non-smoking reference subjects (327 men and 353 women), in two different centers, ten years after the original study (Bull Eur Physiopath Respir 1986;22:217-224). In 535 out of the 680 subjects, forced spirometric measurements were done twice on the same day using a water-sealed spirometer and a pneumotachograph in random order. Equipment was calibrated prior to the protocol using the flow generator system proposed by the American Thoracic Society. Daily calibration and volume checking before each study were done using a 3-L syringe. Despite that significant differences due to the type of equipment were observed in both FVC and FEV_1, they only explained 2% of the interindividual variability, as compared with up to 65% of the variability explained by age and height together (50% and 15%, respectively). The variability due to the center was negligible. Reference equations for variables of forced spirometry, static lung volumes (constant-volume body plethysmography) and single-breath CO transfer capacity (DLCOsb) were obtained. It is of note that the cohort effect after ten years follow- up on FVC and FEV_1 was unimportant to be taken into account. We conclude that differences in equipment together with those due to BTPS correction might likely explain a substantial portion of the variability among centers observed in the European Community Respiratory Health Survey (ECRHS) (Eur Respir J. 1994;7:954-960). The present study substantiates the similarities between forced spirometric data observed in the ECRHS and those obtained in the Barcelona's reference subjects which, in turn, confirms that the reference equations for forced spirometry proposed by the European Respiratory Society underestimate FVC and FEV_1.

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OF-99-066

LONGITUDINAL DECAY OF SINGLE-BREATH CO DIFFUSING CAPACITY IN NORMAL SUBJECTS: 10 YEARS FOLLOW-UP

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Recently, it has been reported that DLCO is a predictor of all-cause mortality within the general population independent of FEV_1 and even in absence of apparent clinical respiratory disease (Am J Epidem 1998; 147:1001-18). We examined 126 (54M/72W) subjects from Barcelona study (ARRD 1990;141:1026-32) explored twice 10 years apart, to investigate: a)the longitudinal decay of DLCO during the 10-yr follow-up period, expressed either in absolute or percent change, was strongly dependent on the initial DLCO value ($DLCO_{initial}$). The latter explained up to 80% of the variance of the final DLCO ($DLCO_{final}$). Different covariates such as changes throughout the study in FVC, FEV_1, height, BMI and time of follow-up explained all together less than 2.5% of the variance of $DLCO_{final}$. A linear equation model did not show homoscedasticity. In contrast a logarithmic transformation of DLCO presented: a) slightly improved predictability of $DLCO_{final}$; b) homoscedascidity; and, c) the constant term of the equation was negligible. The formula proposed to predict the longitudinal decay of DLCO is:

$DLCO_{final}= (DLCO_{initial})^{0.977}$. High reliability of DLCO measurements of DLCO was demonstrated by means of structural equation models with latent variables.

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OF-99-067

ANALYSIS OF CONSTANT WORK EXERCISE TO EVALUATE THE EFFECT OF THE PHYSICAL TRAINING IN THE CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)

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The effect of a program of physical training was analyzed with high work intensity (>70% of the VO_2 pick) of eight weeks of duration in patient with COPD (n=8, 64±4) years; FEV1 45±11% pred; PaO_2, 71±8 mmHg; and, $PaCO_2$ 35±3 mmHg), by an exercise to constant load of low intensity. Before and after the training were measured: 1) whole-body uptake (VO_2) during an incremental exercise with cycloergometer; 2) VO_2 during submaximal exercise constant work rate to 20%, 40% and 60% of maximal exercise pre-training; and, 3) 31 phosphor spectroscopy (^{31}P-NMRS) of the femoral quadriceps during the exercise. After the training, the incremental exercise only detected a significant increase of the maximal work (+15±1.9 watts) (p = 0.005). However, the exercise to constant work rate (40% of the maximum work pre-training) showed: 1) improvement in the kinetics of the VO_2 (the time constant of the VO_2 diminished -11±8 s^{-1}) (p = 0.003); and, 2) decrease of the VO_2 (-102±56 mL.min^{-1}) (p = 0.001), VCO_2 (-102±62 mL.min^{-1}) (p = 0.002) and V_E (-2.0±1.3 L.min^{-1}) (p = 0.05) to the four minutes of beginning of the submaximal exercise. The ^{31}P-NMRS also showed training effect for the decrease of the half time recovery of phosphocreatinine (from 50±8 to 34±7 s) (p=0.02), and increasing the intracellular pH (from 6.83 to 6.98) (p=0.04) and decrease the relationship of [Pi]/[PCr] (from 1.6±0.9 to 0.8±0.7) (p=0.05) to a certain submaximal exercise. Also, the fall of the VO_2 observed after the physical training were correlated with the increment of the intracellular pH (r = 0.78). An association was observed among the improvement of the kinetics of the VO_2 to constant work with the reduction of the constant of time of the recovery of the [PCr] after the training. We conclude that: 1) the exercise to constant work can be useful for the evaluation of the results of a program of physical training in patient with COPD; and, 2) the correlation among fall of the VO_2 and the increase of the intracellular pH, suggests that the effect of the physical training would take place, mainly, at level of the skeletal muscle. (Supported in part by: FIS 97-0794, 1997 SGR-008)

OF-99-069

TIDAL VOLUME (V_T) SIZE DOES NOT AFFECT PHYSIOLOGIC DEADSPACE TO TIDAL VOLUME RATIO (V_D/V_T) IN THE EARLY PHASE OF THE ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS)

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Background: V_D/V_T appears unaltered over a wide range of large V_T's (10-23 mL/kg).(1) We measured V_D/V_T during the first 24 hours of ARDS and evaluated the effect of smaller V_T sizes on V_D/V_T.

Methods: V_D/V_T was measured in 96 patients with ARDS on Assist/Control ventilation at the V_T used for clinical management. The fractional concentration of expired carbon dioxide (CO_2) was measured with a Deltatrac metabolic monitor (2) and an arterial blood gas was obtained during 5 minutes of expired gas collection. V_T was corrected for compressible circuit loss and normalized to ideal body weight. Mean partial pressure of expired CO_2 was corrected for compressible volume dilution.(2) Simple regression analysis was done comparing V_T to V_D/V_T. The mean V_D/V_T of patients whose V_T fell outside of ± 1 mL/kg of the sample mean were compared using a Wilcoxon Signed Rank test. Alpha was set at 0.05.

Results: Mean (± standard deviation) corrected V_D/V_T was .55 (±.11) and the mean V_T was 10.1 (±1.3) mL/kg. V_T ranged from 5.9 to 13.5 mL/kg. No correlation was found between V_T and V_D/V_T (R = 0.11; p = 0.32). Fourteen patients had a mean V_T = 7.9 (± .75) mL/kg with a mean V_D/V_T = .57 (± .11), and 18 patients had a V_T = 11.8 (± .76) mL/kg with a V_D/V_T = .54 (± .09). V_D/V_T was not different (p = .69).

Conclusions: V_T size doesn't appear to influence V_D/V_T in early ARDS. This indicates that a lower V_T may not adversely affect pulmonary CO_2 gas exchange function in early ARDS.

1.Hedley-Whyte J, Pontoppidan H, Morris MJ: The response of patients with respiratory failure and cardiopulmonary disease to different levels of constant volume ventilation. *J Clin Invest*. 1966; 45: 1543-1554.
2.Lum L, Saville A, Venkataraman ST: Accuracy of physiologic deadspace measurement in intubated pediatric patients using a metabolic monitor: Comparison with the douglas bag method. *Crit Care Med*. 1998;26: 760-754.

OF-99-097

RELATIONSHIP OF AIRWAY PLATEAU PRESSURE (P_{PLAT}), QUASI-STATIC RESPIRATORY SYSTEM COMPLIANCE (C_{RS}) AND PULMONARY OXYGEN EXCHANGE FUNCTION TO THE PHYSIOLOGIC DEADSPACE TO TIDAL VOLUME RATIO (VD/VT) EARLY IN THE ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS)

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Background: V_T size does not alter V_D/V_T, but the ratio of V_T/peak tracheal pressure is correlated to V_D/V_T.(1) Both V_D/V_T and the arterial oxygen tension-to-inspired oxygen concentration ratio (PaO_2/FiO_2) are indices of ventilation/perfusion function. We evaluated P_{PLAT},C_{RS}, and P_{PLAT}/V_T(mL/kg) as indicators of lung mechanics to V_D/V_T. The effect of ventilation mechanics on carbon dioxide (CO_2) gas exchange function in early ARDS, were assessed and compared to the relationship between V_D/V_T and PaO_2/FiO_2.

Methods: V_D/V_T was measured on Assist/Control ventilation in 96 patients within the first 24 hours of ARDS. An arterial blood gas was obtained during measurement of mean expired CO_2 concentration with a Deltatrac metabolic monitor (2). Mean partial pressure of expired CO_2 was corrected for compressible volume dilution.(2) V_T was corrected for compressible circuit loss and C_{RS} was expressed as $V_T \div [P_{PLAT}$ -Positive End-Expiratory Pressure]. Simple regression analysis was done comparing P_{PLAT}, C_{RS}, P_{PLAT}/V_T (mL/kg) and PaO_2/FiO_2 to V_D/V_T.

Results: Mean ± standard deviation (sd) V_D/V_T was 0.55 (± .11) and mean V_T was 10.1 (±1.2) mL/kg ideal body weight. Ventilation mechanics correlated poorly with V_D/V_T compared to PaO_2/FiO_2

	P_{PLAT} cmH_2O	C_{RS} ML/ cmH_2O	P_{PLAT}/V_T cmH_2O/mL/kg	PaO_2/FiO_2
Mean ± sd	32.4 ± 8.6	31.1 ± 11.4	3.3 ± 0.97	144 ± 60
Correlation Coefficient	0.20	-0.32	0.24	-0.53
p	0.05	0.002	0.02	< 0.0001

Conclusions: Lung mechanics appear poorly related to V_D/V_T compared to PaO_2/FiO_2. This indicates that in early ARDS pulmonary perfusion abnormalities may be more important in CO_2 gas exchange than ventilation mechanics.

1.Hedley-Whyte J, Pontoppidan H, Morris MJ: The response of patients with respiratory failure and cardiopulmonary disease to different levels of constant volume ventilation. J Clin Invest. 1966; 45: 1543-1554.
2.Lum L, Saville A, Venkataraman ST: Accuracy of physiologic deadspace measurement in intubated pediatric patients using a metabolic monitor. Crit Care Med. 1998;26: 760-754.

OF-99-096

INVESTIGATING THE EFFECTS OF MOVING THE EMERGENCY DEPARTMENT FARTHER FROM THE ABG LABORATORY ON THE TIME REQUIRED TO DRAW AND REPORT THE RESULTS OF ARTERIAL BLOOD GASES

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BACKGROUND As with most, if not all, acute care hospitals, United Regional Health Care System has undergone numerous structural additions and remodeling. In early 1997 plans were released concerning the movement of the Emergency Department (ED) of the Eleventh Street campus. Emergency Department physicians were concerned that moving the ED further from the ABG Laboratory would cause an increase in the time required to report the results of ABGs. We investigated the effects of moving the ED on the time required to report arterial blood gas results drawn from patients in the ED. It is the responsibility of Respiratory Care to draw, run, and report all blood gases in the ED. **METHODS** To investigate this move we compared the time elapsed from the "ordered" time to the "resulted" time before and after the ED moved locations. This was a retrospective study. We compared the average elapsed time one-month prior to the move to the elapsed time one-month after the move. We also investigated the staff "workloads" during the same times to control for possible differing workloads. Before and after results were analyzed with the Student's t-test. P<0.05 determined statistical significance. **RESULTS** The elapsed time before and after the move were 32.6±51.4 and 28.6±44.4 minutes respectively (mean±SD, n=41 before and n=63 after). There was no difference between the elapsed times before and after the move (p=0.7116). The total respiratory workloads before and after the move were 234.4±40.4 and 239.3±40.5 units respectively for the corresponding months. There was no difference between the workloads before and after the move (p=0.6348). **EXPERIENCE** Prior to the move there was some physician and staff concern regarding possible negative effects of increase elapsed time on patient care. No complaints have been reported since the move. **CONCLUSIONS** We found that there were no data to indicate that elapsed times had suffered as a result of change in location of the ED. No additional changes in ED blood gas procedures were necessary. This study was completed as part of the BSRC degree requirements at Midwestern State University.

OF-99-122

REDUCING ABG AND CXR UTILIZATION IN A SICU - Jeff Carlson RRT,
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Background: An ordering practice review in our hospital focused on ABG and CXR utilization in the SICU. We felt that we could develop protocols and/or guidelines and thus decrease utilization by 30%. Outcome monitoring would assess goals and assure no significant negative impact on quality occurred. Our patients routinely had ABG's ordered q am and after most ventilator changes. CXR's were obtained q am and after invasive line procedures. **Method:** Literature review and discussion of practice patterns helped determine criteria for ABG and CXR guidelines. The ICU populations targeted included surgery, vascular, and trauma patients. ABG and CXR utilization rates were determined by analyzing the total number of ABG's or CXR's obtained per day and then were compared to daily unit census. Costs were determined by assessing actual hospital costs associated with obtaining and processing ABG's and analyzing the costs associated with performing, processing, and filing the CXR's. Outcome measures were reviewed daily and weekly through both multidisciplinary rounds along with weekly Quality Improvement Committee meetings. **Results:** ABG utilization decreased 30% over a five month period. In addition, CXR utilization decreased 70%. There was no significant increase in stat orders for CXR's. No significant negative outcomes were noted. This included unscheduled returns to the ICU, length of stay in the ICU, and unexpected events or complications. **Experience:** Attending physicians have adapted to the changes and continue to focus on assessment of the patient. They review the residents' findings and plans along with discussing appropriate ordering and utilization of ABG's/CXR's. Conclusion: Appropriate use of ABG's and CXR's can be achieved through guidelines or protocols. We have experienced no adverse events related to institution of unit ordering guidelines. Cost reduction from these two initiatives amounted to over $27,000 for the five month period.

OF-99-137

SAFETY AND TOLERANCE OF THE PRESSURE-VOLUME (PV)CURVE MEASUREMENT USING A MODIFIED SUPERSYRINGE TECHNIQUE

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Pressure volume curve analysis may be a useful tool to optimize ventilatory settings in patients with acute lung injury (ALI) and acute respiratory distress syndrome (ARDS). Few studies have reported on the safety of the PV curve measurement. We measured static inspiratory PV curves in patients with ALI/ARDS using a modified super-syringe technique, and monitored heart rate (HR), blood pressure (BP), and pulse oxygen saturation (SpO2) immediately prior to, during, and immediately following the PV curve measurement. We also monitored patients for adverse events such as clinical barotrauma. Eleven patients (PaO2/FiO2 160±11.1mm Hg,and Apache score of 25±1.9) had serial PV curves performed for 2 to 7 days. On each day the PV curve measurement was performed in triplicate. The study was terminated if the patient developed hypotension (systolic BP<90 mm Hg.) or hypoxemia (SpO2 <85%) on two successive days. The patients were excluded if they were unable to tolerate a reduction in PEEP to 0 cm H2O (ZEEP), were hemodynamically unstable, or had obstructive lung disease. Starting from ZEEP, The patients' lungs were inflated in increments of 50-100 cc with a 100 cc syringe filled with 100% oxygen until an airway pressure of 45 cm H2O was reached. We present the mean group HR and mean arterial pressure (MAP), recorded pre and post PV curve measurement, and SpO2, recorded pre, post, and at the nadir during the PV curve measurement.

	HR(n=134)	MAP(n=134)	SpO2(n=91)
PRE	109±1.9	93±1.2	92±0.4
NADIR	--	--	89±0.5*
POST	111±1.9	100±1.5*	96.2±0.4*

*p<0.05 vs pre values are mean ±SD

The study was discontinued in 2 patients: in 1 because of inability to tolerate ZEEP, and in another because of subcutaneous emphysema that developed on day 3 of the study. In 1 patient the systolic BP dropped to 64 mmHg. and in a second patient the SpO2 dropped to 79% . These effects were transient and did not result in termination of the study. In all other cases measurement of the PV curve was safe and well tolerated. Although the PV curve may aid in setting ventilatory parameters to reduce VILI, physiological changes do occur. Thus careful monitoring of vital signs, oxygen saturation, and signs of barotrauma is critical when performing these types of procedures.

OF-99-157

IMPROVING THE QUALITY OF BEDSIDE SPIROMETRY.

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BACKGROUND: A 1998 audit of spirometry tests done at our institution outside of the Pulmonary Function Laboratory revealed a low percentage (17%) of bedside spirometry tests meeting ATS acceptability and reproducibility criteria.

METHODS: We initiated an improvement plan that included the following features:

1. Review of ATS acceptability and reproducibility criteria that was videotaped and made available to all therapists performing spirometry.
2. Limiting the number of operators to a 'core group' to allow more tests/therapist.
3. Availability of hardcopy printouts that allow review of volume-time and flow-volume curves.
4 Central review of all tests by a Pulmonary Function Technologist with constructive feedback on test quality, reproducibility and suggestions for improvement to the operators.

RESULTS: Throughout the course of our review of spirometry tests, the overall percentage of tests judged to be acceptable and reproducible was 63.5%. This was significantly better than our initial audit (17% acceptable and reproducible, P=<0.001, Chi-square). FVC and FEV1 were reproducible in 75.9% of the testing sessions.

CONCLUSIONS: Our findings suggest that a quality improvement program for bedside spirometry testing that emphasizes a working knowledge of ATS acceptability criteria and review of tests with feedback on test quality can have positive measurable results.

OF-99-161

THE NEED FOR EARLY DIAGNOSIS AND TREATMENT OF TRAUMATIC DIAPHRAGMATIC RUPTURE: A CASE PRESENTATION AND REVIEW OF THE LITERATURE - Om P. Sharma, MD, FACS, Pamela L. Bortner, MBA, RRT, Jennifer A. Wadas, MS/MEd, MBA, RRT, Scott L. Dunavant, MD, Ashraf F. Banoub, MD, The Toledo Hospital and Toledo Children's Hospital, 2142 North Cove Boulevard, Toledo, Ohio 43606

INTRODUCTION: Traumatic diaphragmatic rupture (TDR), although uncommon, is being diagnosed more frequently by health care professionals. Timely treatment is essential because of the high incidence of associated trauma and sequelae of delayed diagnosis such as incarcerated hernia. Thorough clinical evaluation, radiological investigations, computerized tomography (CT) and other diagnostic studies lead to a correct and timely diagnosis. A case involving a five-day delay in diagnosis with incarceration of left colon and spleen is presented. CASE SUMMARY: This case involves a 71-year-old male restrained driver involved in a motor vehicle crash. The patient was hypotensive at the scene. Upon arrival at this Level II trauma center, a chest radiograph was normal. A CT scan of the abdomen revealed multiple left-sided rib fractures and left lower lobe pleural fluid accumulation. A chest tube was placed prophylactically prior to surgery for reduction of an open left femur shaft and closed left radial fractures. Five days post-trauma, a repeat chest radiograph was suggestive of left diaphragmatic hernia. A repeat CT scan confirmed this diagnosis with herniation of the colon and spleen. The patient underwent successful surgical repair of the TDR. The post-operative period was uneventful. DISCUSSION: TDR occurs on the left side in 78% of all cases of diaphragmatic rupture. Two-thirds of the patients have an associated intra-abdominal trauma. Commonly associated thoracic injuries include rib fractures, hemothorax, pneumothorax, pulmonary contusion and flail chest. A chest radiograph depicting a bowel hernia through the defect is seen in 27-37% of the cases. The initial chest radiograph may be normal in patients on mechanical ventilation with PEEP. Subsequently, when the PEEP is discontinued or the patient is extubated, a hernia may become manifest with a diagnostic chest radiograph. Rarely, a CT scan may reveal diaphragmatic defect as was the case in this patient. It is not uncommon to diagnose a left diaphragmatic hernia in a delayed phase, months to years after the initial trauma. Careful patient evaluation and thorough investigations are essential for early diagnosis and to prevent the complications of delayed treatment.

OF-99-166

INTRAOPERATIVE AND POSTOPERATIVE ASSESSMENT OF POSITIVE PRESSURE VENTILATIONS EFFECT ON CARDIAC OUTPUT AND PULMONARY CAPILLARY BLOOD FLOW

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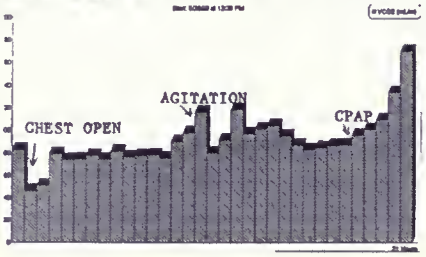
A case of hypovolemia, decreased cardiac output, and diminished pulmonary capillary blood flow reflected through monitoring volumetric CO_2 [CO_2 production (VCO_2) and deadspace (Vd/Vt)].

A ninety year old female patient admitted for bursitis of the shoulder was diagnosed with coronary artery occlusion resulting in angina.

Worked up for coronary artery bypass graft (CABO) surgery, prepped in the preanesthesia laboratory the patient was assessed and followed during surgery as well as postoperatively in the intensive care unit (ICU).

After the patient was intubated the Novametrix, CO_2SMO PLUS Respiratory Profile Monitor was placed common to inspiration and expiration and anesthesia induction continued. Respiratory parameters were continuously monitored and trended, see graft below. Volumetric CO_2 (VCO_2) diminished progressively as Positive Pressure Ventilation (PPV) was initiated and throughout the entire case, as the patient was not placed on cardiopulmonary bypass. Periods of hand bagging off the ventilator led to even lower VCO_2 with increased deadspace (Vd/Vt). During the following 12 hours postoperative recovery in the ICU, hypertension, agitation and adequate pain management hampered liberation from the ventilator. Cardiac output (CO) was 3.8L/M and VCO_2 was 50ml/min. Fluid resuscitation was not considered an option as the patients left ventricular ejection fraction was < 50%. The patient was challenged to breathe spontaneously on continuous postive airway pressure (CPAP). VCO_2 steadily increased, rapid shallow breathing index (f/Vt) was <100. The patient was successfully liberated and extubated without any sequelae. It appears that monitoring VCO2 can empower the RCP to safely and correctly adjust and fine tune weaning strategy, limit blood gas usage and possibly decrease mechanical ventilation time.



OF-99-182

DIAGNOSTIC VALUE OF FLOW-VOLUME LOOP DURING SPIROMETRY

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Flow volume Loop provides invaluable information on the lung function characteristics. The understanding of genesis of the flow-volume loop allows uncovering many disorders of inspiratory and expiratory phases of the breathing cycle. In current practice flow-volume loop is obtained as a part of the routine spirometry. Many office spirometers are equipped with this application. When performed in erect and supine positions Flow-volume loop can reveal underlying variable airway obstruction. The authors present one case of symptomatic postural airway obstruction to illustrate this point.

A 46-year-old African American woman presented with dyspnea upon lying down and exertion. The physical examination revealed a mass in the neck consistent with enlarged thyroid. A flow-volume loop obtained in sitting position was normal. However, when the study was repeated in supine position the flattening of the inspiratory limb of the Flow-volume loop became obvious indicating the variable extrathoracic obstruction. The patient underwent total thyroidectomy. Her symptoms resolved postoperatively. Later, a repeat study of Flow-volume loop was normal both in erect and supine positions.

OF-99-191

PROPHYLACTIC USE OF VA ECMO DURING A POTENTIALLY LIFE-THREATENING CARDIAC PROCEDURE.

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This case presentation demonstrates the prophylactic use of venous-arterial extracorporeal membrane oxygenation (VA ECMO) during a high-risk interventional cardiac catheterization. The patient was a 2.5 kilogram, 37 week gestational age (WGA) twin B female diagnosed *in utero* at 29 WGA with Ebstein's anomaly.[1] Her APGAR scores were 6 (1 min) and 8 (5 min), and she was admitted to a level III nursery where she was intubated and started on prostaglandin E_1. She was desaturated at the time of transfer to our cardiac ICU, and inhaled nitric oxide (NO) was started as a selective pulmonary vasodilator. After 24 hours she developed episodes of supraventricular tachycardia (SVT) due to reentry over an uncommon type of accessory conduction pathway known as a Mahaim fiber. These episodes were accompanied by severe hypotension, at times requiring cardiac massage, and treatment with the antiarrhythmic agents digoxin, procainamide, and amiodarone all failed to control the SVT. The best solution was to perform a radiofrequency catheter ablation of the Mahaim fiber. This was problematic because of the patient's small size, the severity of hypotension in tachycardia, and the fact that pathway mapping could only be performed during SVT. VA ECMO was considered to be a viable means of support during this potentially lengthy and difficult procedure. Under controlled circumstances in the ICU, she was cannulated with a #10 Biomedicus venous cannula in the right internal jugular vein and a #8 Biomedicus arterial cannula in the right common carotid artery. The flowrate was 110cc/kg/min and the sweep gas 3/4L carbogen and 1/4L oxygen. Transport on ECMO to and from the catheterization laboratory was uneventful, and pathway mapping and ablation were arduous but successful. There were no complications on ECMO and she was decannulated after 72 hours. SVT was not inducible in follow-up testing. She was extubated 9 days later to nasal cannula NO and is presently home without obvious sequelae. In summary, while ECMO is traditionally used to salvage patients with pulmonary and/or cardiac failure that is refractory to conventional therapies, we used ECMO proactively in this neonate to prevent a decompensation during a cardiac procedure known to carry high risks.

1. Celermajer, DS, Bull, C, et al. J Am Coll Cardiol 1994;23;170-6.

OF-99-193

CASE STUDY USING HELIOX IN THE CYSTIC FIBROSIS PATIENT IN SEVERE RESPIRATORY DISTRESS

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Introduction: Heliox is used to treat the obstructed airway in the treatment of asthma Therefore we theorized that the same therapy should work for the lung in cystic fibrosis that is hyperinflated and backed up with retained secretions. **History:** The patient is a 15 year old white female with a history of Cystic Fibrosis. The patient had been stable, with her most recent admission for respiratory problems 18 months previous to this clinic visit. Upon arrival to the clinic, a Vbg was obtained via a central line,$Va0_2$ 38, $VC0_2$ 32, Ph 7.42, and bicarbonate 32 on 100% $Fi0_2$. Her respiratory rate was in the 60's with accessory muscle usage. $Sp0_2$ on the 100% $Fi0_2$ was 88-90%. Pulmonary functions were FVC 19% and FEV1 16% of her predicted values and a RV/TLC ratio 85%. Chest radiograph was consistent with hyperinflation and the typical changes of cystic fibrosis. Sputum culture and sensitivity showed resistant Pseudomonas aeruginosa and Staphylococcus aureus. Initial therapy consisted of aerosolized bronchliators, IV antibiotics and IV steroids along with CPT. **Case Study:** The patient showed no signs of improvement after several hours of her initial therapy; her $Sp0_2$ was 85% on 100% FiO_2 with a respiratory rate of 60. Heliox was started from a cylinder containing an 80% helium and 20 % oxygen mixture; additional oxygen was blended in to obtain a 40% helium and 60% oxygen mixture along with a 4 liter a minute nasal cannula Within a five minute period her $Sp0_2$ increased to 95%, her respiratory rate had dropped to the 40's, and she stated that she felt better. A second Vbg was obtained with a marked improvement in the $Va0_2$ from 38 to 95 after one hour. Since her $Sp0_2$ increased, we used the pulse oximetry to wean the oxygen The first wean was to the $Fi0_2$ mixture; then we reversed that move and weaned the cannula off within 3 hours of the initiation of heliox. The helium was at 70% and the oxygen was at 30% after 9 hours Pulmonary function tests performed weekly for the next four weeks indicated an increase in FVC and FEV1 and a decrease in the RV/TLC ratio.

	FVC	FEV1	FEV1/FVC	TGV	RV	TLC	RV/TLC
Admission	19%	16%	82%	179%	380%	96%	85
Day 7	41%	25%	62%	158%	285%	96%	64
Day 14	50%	28%	57%	164%	290%	101%	62
Day 21	50%	33%	65%	154%	258%	96%	58
Day 25	51%	33%	64%	144%	223%	93%	52
Discharge	50%	35%	70%	144%	223%	90%	53

Conclusion: Heliox therapy seemed to be valuable to this patient with severe respiratory distress allowing lower oxygen concentrations and an increase in her sputum production.

OF-99-213

A COMPARISON OF PULMONARY FUNCTION DATA FROM THREE PULMONARY FUNCTION LABORATORIES IN A METROPOLITAN AREA

J. Richard Whitehead, MHS, RRT, RCPT., RPFT; LSU Medical Center, Shreveport, LA.

For decades pulmonary function (PF) testing has been performed to measure various lung volumes and capacities. These PF data results are used by physicians in all aspects of care for patients with pulmonary problems. Because of the integral role of pulmonary function test in patient care, it is imperative that these measurements be an accurate reflection of the patient's lung functions. There is continuous advancements in PF testing technology, but more important, employees often must seek alternative health care providers when employers change health care plans or they change employment. Therefore, there is a need to validate the accuracy of PF data produced between PF testing laboratories within a city or region. Various organizations have published guidelines to standardize all aspects of pulmonary function testing. However, there are only a few publications documenting comparability of data between pulmonary function laboratories using normal subjects as "biological controls." This study evaluated the degree of variability of pulmonary function test measurements between three PF laboratories in a large metropolitan city. It was not the intent of this study to identify the cause of any significant variability but only if differences existed. Eight healthy, non-smoking study subjects performed complete pulmonary function studies at three PF laboratories in our city. Instructions were administered by the same personnel at each PF laboratory to study subjects on three consecutive days at the same time of day. A rotation schedule was developed so that there was equal first, second and third visits to each laboratory. Descriptive statistics were calculated for each of the study subjects on each of the pulmonary function tests measured. A repeated measure univariate analysis was performed on the data. Listed below are averages of individual test differences of the high and low measurements between the laboratories.

SVC = 0.46 L.*
FRC = 0.59 L.*
RV = 0.53 L.
TLC = 0.71 L.*
FVC = 0.47 L.*
FEV1.0s = 0.41 L.*

PEF = 2.00 L/sec*.
FEF $_{25\%-75\%}$ = 0.85 L.
DL$_{CO}$ = 4.38 mL/min/mmHg*
AV/DLCO = 0.78
DL/AV = 0.68

Group measurements indicated with an * show significant variability among the three study sites. All individual averages show significant variability. The results from this study indicate PF testing laboratories should consider reviewing their calibration procedures and quality control protocols and initiating the use of ìbiological controlsî as a part to diagnostic laboratory quality assurance.

OF-99-219

LUNG MECHANICS IN CHEST PHYSICAL THERAPY TECHNIQUES

Tetsuo Miyagawa* Ph D, RRT, PT, RCET and Masaki Shigeta** MD.
*: Department of Physical Therapeutics, College of Medical Sciences, Showa University, Yokohama, 226-8555, Japan. ** : Emergency Life Saving Technique Academy of Tokyo, Tokyo,192-0364,Japan

Background: Chest physical therapy (chest PT) techniques are commonly performed to enhance secretion clearance. However, the effect of these techniques in lung mechanics have not been studied. We have already reported the change in lung mechanics during chest PT techniques, Respir Care 42:1087, 1997 and I also have reported that chest wall percussion and vibration techniques were ineffective, and squeezing techniques were more effective than chest wall percussion in critically ill patients. The purpose of this study was to evaluate the change in lung mechanics using the model lung during application of the chest PT techniques. The theory behind squeezing technique is to improve regional ventilation, expiratory flow and expiratory pressure to enhance mucus movement. **Method:** We measured alveolar pressure (Palv), expiratory flow and tidal volume (V_T) using by Respiratory Monitor OMR-8101 (Nipon Koden Inc. Japan) and Dual Adult TTL (Michigan Instruments Inc. USA) during application of the chest PT techniques. We compared with squeezing, springing and forced expiratory compression (FEC) in spontaneous breathing, volume control ventilation (VCV), pressure support ventilation (PSV) and pressure control ventilation (PCV). Each techniques in each ventilatory mode were applied in normal lung mechanics (C_{ST} 50, R_{AW} 5), stiff lung mechanics (C_{ST} 10, R_{AW} 5) and high airway resistant lung mechanics (C_{ST} 50, R_{AW} 50). **Results:** 1) Spontaneous breathing in normal lung mechanics have expiratory flow 0.8L/sec, Palv 8cmH$_2$O, and V_T 520ml. when squeezing was applied, spontaneous breathing changed to expiratory flow 1.3L/sec, Palv 12cmH$_2$O, and V_T 800ml. 2) When squeezing was applied in high resistant lung, especially, Palv increased. 3) The changes of expiratory flow, V_T and Palv were small at squeezing in stiff lung. 4) V_T increased at only the first squeezing in VCV, But V_T did not change during application from the second squeezing. Expiratory flow and Palv also did not increase. 5) Expiratory flow, V_T and Palv increased at every one time squeezing in VCV. 6) Expiratory flow, V_T and Palv increased during application of squeezing at PCV and PSV. **Conclusions:** Squeezing technique is effective in normal and high resistive lung mechanics and this technique is also effective in spontaneous breathing, PCV, PSV and CPAP mode in mechanically ventilated patients.

OF-99-229

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EVALUATION OF FIVE BENCHTOP BLOOD GAS/ELECTROLYTE/METABOLYTE/CO-OXIMETER ANALYZERS FOR SATELLITE UTILIZATION.

Catherine Foss BS, RRT, RPFT, Mercedes True BS, RRT, RPFT, Fernando Martinez, MD. Pulmonary Diagnostic Services, University of Michigan, Ann Arbor, MI.

Analysis of blood samples for blood gas, saturation, electrolytes, and metabolites plays a vital role in pulmonary and critical care medicine. With a goal to standardize testing throughout our health system and optimize purchasing power we examined five instruments. **Methods:** Five vendors provided analyzers for two weeks including AVL Omni, Chiron 860, Intrumentation Laboratory Synthesis, Nova Stat Profile, and Radiometer 700. Each instrument was calibrated and maintained according to manufacturer's specification, using the vendor's QC. An identical evaluation included precision with quality control material (20 runs), precision utilizing whole blood samples run twice (100 samples), accuracy using QC material and tonometered samples, linearity using QC and tonometered samples (5 levels using IL 237), and comparison to the resident analyzers with split samples (100 samples). A mandatory data management system to network satellite labs was evaluated for each vendor. The evaluation process was performed by lab techs, a supervisor from the reference pulmonary lab and Respiratory Care Practitioners (RCPs) who utilize STAT satellite systems. Staff completed evaluation forms rating the maintenance, ease of use and noted technical difficulties encountered during the study. **Results:** All instruments demonstrated excellent precision with correlation coefficients with the standard ranging from 0.997 to 0.999. All had good correlation with the existing system, IL 1640/682 in all parameters except for dyshemoglobins. High lipid samples affecting the older technology but not the new caused this variation. Linearity was good except for the highest PO2. **Conclusions**: Since all were close in precision, accuracy and linearity, the decision was influenced by sample size, maintenance issues, and data management. The process that was utilized to evaluate the five instruments was vital in providing data for the committee making decisions for purchase.

OF-99-034

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OUTCOME OF ARTERIAL LINE INFECTION RATES.

Hoch, Kristie R.R.T., Barry, Sean M.D., Blake, Shane R.R.T., Poggemeyer, Chad R.R.T, Wyrens, Marcy R.R.T., BryanLGH West, Lincoln, Nebraska

BACKGROUND: An internal quality assurance program was started in response to RCP placement of arterial lines. The authors hypothesized the risk of infection in comparison to length of insertion. Arterial lines were monitored for accuracy, complications and septicemia. In the beginning of the program, lines were changed every 72 hours according to CDC guidelines and then the frequency was increased to every 96 hours. Currently arterial lines remain in place as long as they continue to function properly without sign of infection. METHOD: Each line was monitored for infection through site checks every 8 hours. Sites were redressed if the occlusive dressing became loose. A site with any sign of infection, such as swelling, redness or bruising, was discontinued. Fluids would be changed as needed without changing the line and transducer. Catheter tips were randomly cultured. The charts of all patients receiving arterial lines were reviewed monthly for length of arterial line insertion, accuracy of the line in comparison to non-invasive readings and any positive blood cultures. RESULTS: In the first year, all changes were at 72 hours, 97 arterial lines placed resulted in 8 positive blood cultures. The second year, with changes increased to 96 hours, 157 arterial lines were inserted resulting in no positive blood cultures. These results prompted the Critical Care committee to approve a 6-month study to monitor arterial lines left in as long as they were viable. Results were 1 positive blood culture of the 94 lines reviewed in the 6-month trial. CONCLUSION: Critical, immunosuppressed patients are at risk for complications from infection. Hemodynamic lines placed to monitor critical patients were once thought to increase infectious risk if not changed according to CDC guidelines. The study shows no direct correlation between the length of insertion and risk of infection. Average length of insertion for the 6-month trial was 112 hours, 16 hours greater than the recommended time.

OF-99-039

CORRELATION BETWEEN ETCO$_2$/PCO$_2$ and SPO$_2$/SaO$_2$: AN EVALUATION OF THE NOVAMETRIX CO$_2$SMO *PLUS* RESPIRATORY PROFILE MONITOR

James Formicola, BS, RRT, Heather Libros, RRT, Douglas Oberly, BS, RRT, Elise Sinha, BS, RRT.
Respiratory Care Department, Hartford Hospital, Hartford, CT.

Background: The Novametrix CO$_2$SMO Plus Respiratory Profile Monitor is a monitor that profiles the patient's respiratory status with respiratory mechanics, capnography, and oximetry. Hospitals are consistently finding ways to cut health care costs. This clinical study evaluated the correlation of End-Tidal Carbon Dioxide (ETCO$_2$) with Arterial Carbon Dioxide (PCO$_2$) and the Pulse Oximetry Saturation (SPO$_2$) with Arterial Oxygen Saturation (SaO$_2$) in critically ill, mechanically ventilated patients.
Study Question: Does the CO$_2$SMO Plus accurately represent the PCO$_2$ and SaO$_2$ in critically-ill patients?
Methods: Forty five (45) critically-ill, mechanically ventilated patients in the Medical and Surgical ICU were evaluated. Patients were included in the study if they were intubated and routine blood gases were ordered. Arterial blood gases were obtained via indwelling A-lines and arterial puncture technique. A combined mainstream CO$_2$ capnography/flow sensor from the CO$_2$SMO Plus was placed inline between the endotracheal tube and the wye of the ventilator circuit. The pulse oximetry was measured via finger probe from the CO$_2$SMO Plus. Data was collected by Novametrix software generated by LabView (National Instrumentation). The CO$_2$SMO Plus was placed on the patient for a minimum of three (3) minutes prior to an arterial blood gas being drawn. The ETCO$_2$ and SPO$_2$ were recorded at the time of the blood gas draw. The blood gas was placed on ice and transported to the laboratory for analysis using a Chilon Blood Gas Analyzer/Co-Oximeter (Chilon, Inc.). The PCO$_2$ and SaO$_2$ results of the blood gas were then recorded. Only one evaluation per patient per day was completed.
Results: Data was analyzed using the Pearson Correlation Coefficient test to determine the correlation between ETCO$_2$/PCO$_2$ and SPO$_2$ / SaO$_2$. The correlation factor for the SPO$_2$ / SaO$_2$ was +0.91, which is significant at $p< .001$ when tested against a correlation of 0.00. The correlation factor for the ETCO$_2$/PCO$_2$ was +0.60, which is significant at $p < .001$ when tested against a correlation of 0.00. A cost savings of $2,511.41 would have been recognized if these 45 patients used the CO$_2$SMO Plus during these evaluations.
Conclusion: Our results indicate that the CO$_2$SMO Plus was able to correlate the SPO$_2$ with SaO$_2$ and the ETCO$_2$ with PCO$_2$ in these 45 critically-ill patients. We conclude that a potential cost benefit from less arterial blood gas procedures can be recognized by utilizing the CO$_2$SMO Plus. More studies must be conducted to differentiate disease process and the response to the CO$_2$SMO Plus.

OF-99-058

Symposium #5: Monitoring

HIGH DOSE TRIS-HYDROXYMETHYL AMINOMETHANE (THAM) REDUCES ARTERIAL CARBON DIOXIDE TENSION (PACO2) DURING PERMISSIVE HYPERCAPNEIC VENTILATION (PHV) IN PATIENTS WITH ACUTE LUNG INJURY (ALI)

RH Kallet MS RRT, RM Jasmer MD,L. Lin MD, JM Luce MD, JD Marks MD;
Department of Anesthesia University of California, San Francisco at San Francisco General Hospital, 1001 Potrero Ave. San Francisco, CA 94110

Background: PHV in ALI requires induced respiratory acidosis that may compromise cellular function in the presence of metabolic acidosis and shock. The renal excretion of protonated THAM lowers CO2 production in metabolic acidosis(1) and directly lowers PaCO2.(2) We report the use of THAM in 4 cases of PHV and one case of severe acidosis with eucapnea in ALI.

Methods: THAM was administered at a mean dose of 2.1 ± standard deviation (sd) of 1.63 mmol/kg/hour. Arterial blood gases were taken before, and within an hour after THAM started. Alveolar ventilation ($\dot{V}$A) was calculated from measurements of minute ventilation and physiologic deadspace. Deadspace was measured on Assist/Control ventilation using a Deltatrac metabolic monitor (3) Wilcoxon Sign-Rank tests were used for paired comparisons (Alpha = 0.05.).

Results: Mean PaCO2 was significantly lower at equivalent levels of $\dot{V}$A.

Pre-THAM				Post-THAM		
Case	pHa	PaCO2 mmHg	$\dot{V}$A L/min	pHa	PaCO2 mmHg	$\dot{V}$A L/min
1	7.18	110	7.6	7.26	95	7.9
2	7.07	39	11.5	7.34	30	11.5
3	7.14	66	10.4	7.26	51	10.4
4	7.09	52	16.0	7.12	44	13.9
5	7.11	60	18.8	7.31	44	13.7
Mean	7.12	65.4	12.9	7.26†	52.8†	11.5
± sd	± .04	± 26.9	± 4.5	± .08	± 24.8	± 2.5

†P < 0.05.

Conclusions: High dose THAM directly lowers PaCO2. Buffering acidosis with THAM may facilitate the use of PHV during ALI.

1.Nahas G, Reveillaud A, Strauss J: Renal effects of tris (hydroxymethyl) aminomethane during CO2 load. *Am J Physiol.* 1963; 204(1): 113-118.
2.Nahas G: Use of an organic carbon dioxide buffer in vivo. *Science* 1959; 129: 782-783.
3.Lum L, Saville A, Venkataraman ST: Accuracy of physiologic deadspace measurement in intubated pediatric patients using a metabolic monitor: Comparison with the douglas bag method. *Crit Care Med.* 1998;26: 760-754.

OF-99-095

EVALUATION OF THE VIA LVM EX-VIVO BLOOD GAS AND CHEMISTRY MONITOR.

Richard Lawhead, BS, RRT, CPFT, P/P Spec., Patty Munro, RRT, Mark Heullit, MD, Arkansas Children's Hospital

Background: The VIA LVM is a bedside, in-line, ex-vivo monitor designed to provide real-time results for blood gases, electrolytes, and hematocrit. A specialized VIA stopcock allows the system to be used concurrently with existing arterial or central venous lines. On demand, 1.5mLs of blood are gently drawn from the patient into the sensor with measured values for pH, pCO_2, pO_2, Na^+, K^+, and Hct being obtained in 70 seconds. All but 0.02mL of blood is returned to the patient with a 0.5mL flush.
Methods: Patients in our NICU, CVICU, and PICU who had either an arterial or central venous line in place were selected. When an ABG/VBG was scheduled, a paired-sample analysis was performed. As the VIA LVM was in the process of analyzing blood drawn from the patient, the VIA stopcock was manually turned off to the sensor and blood was drawn for routine analysis and immediately sent to the STAT Lab for processing (Chiron 865). Draw times and run times were recorded for each sample. Questionnaires were also provided to receive subjective evaluation from the staff.
Results: 115 paired samples were obtained from 12 patients over a five-day period. Age range was from 26 weeks gestation to 1 year old. Weight range was from 620 grams to 9.6 kg. No complications linked to the VIA were noted.

	pH	pCO_2	pO_2	pO_2(%)	Na^+	K^+	Hct
Bias	0.01	-1.2	3.4	2%	2.7	-0.1	1.7
Precision	0.02	3.2	9.9	10%	2.3	0.2	2.6
Min	7.24	23.5	20.8	20.8	130	2.5	30
Max	7.58	63.1	230.6	230.6	151	5.0	55
# of pts	115	115	115	115	114	114	111

Experience: Blood draw for laboratory tests in the neonatal population often leads to multiple transfusions secondary to iatrogenic blood loss. Frequent blood gases and chemistry values are often needed to optimize care in the critically ill child.
Conclusions: The VIA LVM system was found to be precise and accurate when utilizing both CLIA accepted standards and Bland and Altman statistical analysis. The potential advantages of monitoring with the VIA LVM include reduced need for blood transfusions, decreased infection risk to the patient, instantaneous resulting of values, the ability to monitor values frequently at a relatively fixed cost, and significant reduction in pre-analytical error.

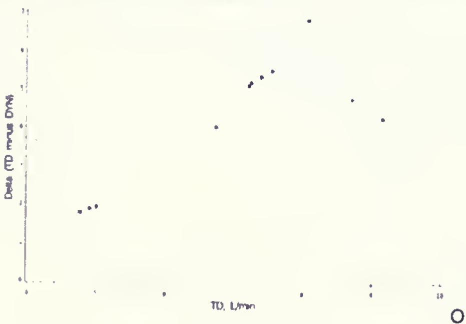
OF-99-116

THE DYNEMO 3000* IS NOT ACCURATE IN MEASURING CARDIAC OUTPUT IN CRITICALLY ILL PATIENTS.

J. FLOTTUM, D. FEARN, H. TLOUGAN, N. MATZKE, D. SAKIC , R. VENABLE, J. WARD M. Ed. RRT, DAVID PLEVAK, MD; ROCHESTER COMMUNTY & TECHNICAL COLLEGE-MAYO FOUNDATION, ROCHESTER, MN

Background: The Dynemo 3000 (DYN) (Sometec Inc., Stoneham, MA) uses a transesphageal probe and Doppler technology to determine cardiac output (CO). We performed this investigation to compare measurements made by DYN with those obtained from thermodilution (TD) by a pulmonary artery (PA) catheter. Since this device measures only CO flowing through the descending aorta, we felt that the device would be of benefit to our practice if (TD-DYN) bias was between 25-35% and precision was less than1.5 L/min.
Methods: After obtaining permission from the IRB a total of 11 measurements were obtained from 5 patients in an ICU setting. All patients were orally intubated, sedated and had a PA catheter. The DYN probe was inserted through the oral cavity and into the esophagus. The aortic diameter was determined by Doppler method and CO was calculated by measuring flow through the descending aorta. DYN CO was recorded while TD CO was taken to be the result of the mean of the 2nd and 3rd PA catheter injections. Data analysis included simple regression. A Bland - Altman plot was constructed (see Fig. 1). .
Results: Mean bias: 4.19 L/min. Precision (+/-2STD): 3.34. Correlation coefficient (r^2): 0.028.
Conclusion: The data from the Dynemo exceeded the range of bias and precision that would have made it useful to our practice.

Fig. 1.

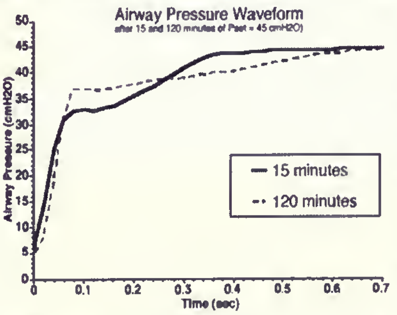


OF-99-125

CHANGE IN THE INSPIRATORY AIRWAY PRESSURE WAVEFORM MAY BE A MARKER FOR VENTILATOR INDUCED LUNG INJURY.

Alexander Adams RRT, Mary Stone RRT, Laurel Wright MD, Gül Gürsel MD, John Marini MD. Regions Hospital, University of Minnesota, St. Paul, MN.

Introduction: In ARDS patients, a biphasic profile characterizes lung volume decay during passive expiration. The inspiratory airway pressure waveform (IAPW) during pressure control ventilation (PCV) is less well studied but is generally thought to approximate a uniexponential washin function. Changes in the IAPW may serve as a marker of lung injury induced by mechanical ventilation. In a model of ventilator induced lung injury (VILI), we examined the IAPW before and after high airway pressure exposure to identify changes that may correlate with the development of VILI. **Methods:** Nine New Zealand white rabbits were anesthetized, paralyzed and instrumented to monitor ABGs, FRC and airway pressure. Injury was induced by PCV at Pset = 45 cmH2O for 2 hours, PEEP = 3 cmH2O, f = 23/min, and TI = 1.0 sec (FIO2 = 0.4). On the IAPW, we compared the time to attain 35, 40, 45 cmH2O and goodness of fit of a uniexponential curve between 15 min and 120 min of the experimental period. **Results:** Two hours of PCV caused reductions in PaO2 (-159.9 mmHg), FRC (-34%) and compliance (-66%). Consistent changes in IAPW were also seen (example in figure). The mean time to attain 35 cmH2O decreased (p=.048). The mean times to attain 40 and 45 cmH2O increased significantly (p =0.016, p =.001). The uniexponential curve fit worsened as VILI developed. **Conclusions:** Change in the IAPW occurred during VILI: the pressure increase period lengthened and became more linear. A change in lung impedance and the reaction of the ventilator's flow metering algorithm may cause the IAPW change. Such alterations in the IAPW might serve as a marker of VILI.



OF-99-134

THE USE OF VCO2 IN PREDICTING SUCCESSFUL LIBERATION FROM MECHANICAL VENTILATION.

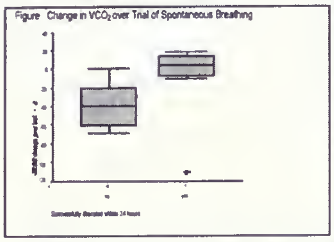
John H. Boynton Jr. R.R.T. Grant O'Keefe M.D. Parkland Health & Hospital Systems 5201 Harry Hines Blvd.Dallas,Texas 75235

BACKGROUND. Present indicators of successful liberation from mechanical ventilation (MV) may not be accurate in patients who have received prolonged MV. Patients who successfully complete a trial of spontaneous breathing are still at risk of fatiguing post extubation. We sought to determine whether changes in VCO2 may indicate decreased gas exchange and predict subsequent fatigue.

METHOD: The following data was recorded at baseline and at 5 minute intervals during CPAP utilizing a Novametrix Cosmo+ interfaced with a lap top computer. VCO2, respiratory rate, arterial saturation, and expired volumes. Data was collected for 2 hrs on stable patients.

RESULTS: Seventeen patients underwent a trial of spontaneous breathing and were included in this study. The median duration of MV prior to the study was 18 days. Respiratory failure was secondary to multiple trauma in 10 patients and followed emergency or elective surgical procedures in the other 7. The following comparisons are between the 7 patients successfully liberated within 24 hours and the 10 were not. The duration of MV prior to being studied was not different between the 2 groups. Standard weaning parameters, including the spontaneous respiratory rate, Pmax, minute ventilation and RSBI were not different between those successfully liberated within 24 hours and those who were not. VCO2 prior to starting the trial was not different between those successfully liberated and those who were not (213±60 vs. 234±48 respectively). As indicated in the figure, VCO2 decrease to a significantly greater degree in patients who were not successfully liberated within 24 hours.The results of the trail were not known prior to extubation.

Figure Change in VCO_2 over Trial of Spontaneous Breathing



CONCLUSIONS: A decreasing VCO2 during a trial of spontaneous breathing may indicate deteriorating gas exchange and fatigue. The preliminary data presented suggest that monitoring VCO2 during a trial of spontaneous breathing may be helpful in determining who will be successfully liberated from MV and aid in the decision to extubate or continue with gradual reduction in support.

OF-99-135

MONITORING PROXIMAL (Pamp) AND CARINAL AMPLITUDE (Camp) CHANGES TO IDENTIFY CHANGES IN AIRWAY RESISTANCE AND LUNG COMPLIANCE DURING HIGH FREQUENCY OSCILLATORY VENTILATION (HFOV).

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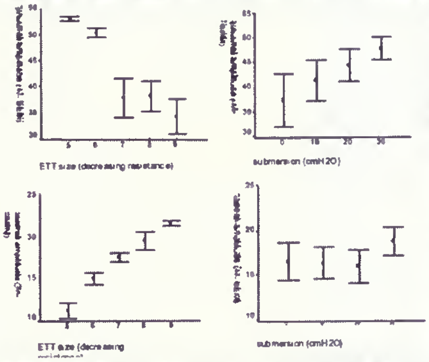
BACKGROUND: HFOV is one option employed in the treatment of pediatric and adult patients with severe respiratory failure who fail conventional ventilation. Some difficulties in its application may be responsible for the lack of wider utilization. Specifically, endotracheal suctioning causes alveolar derecruitment, hypoxia, bradycardia, and hemodynamic instability. We sought a mechanism to reduce the occurrence of unnecessary suctioning.

METHOD: A SensorMedics 3100a ventilator was attached to a multiple balloon lung model. A mechanics monitor (Novametrix Cosmo+) was interfaced with a laptop computer and adapted to measure pressure changes distal to the end of an endotracheal tube (Camp). Pamp was read from the digital display of the 3100a ventilator and parameters were set as follows: Paw 35 cmH20; Hz 6; Power 6.0; bias flow rate 40 lpm and % I Time .33. Changes in Raw were created by varying endotracheal tube sizes (5,6,7,8,and 9). The lung model was positioned in a 50 gallon aquarium at depths of 0, 10, 20, and 30 cmH20 to simulate compliance changes. Camp was captured by measuring the pressure change between peak and trough of oscillations as recorded by the mechanics monitor and had a deviation of ± .7 cmH20.



RESULTS: Increasing Raw (Smaller ETT diameter) resulted in an increasing Pamp and a decrease in Camp (P<0.001 for both - see figure). Decrease compliance also resulted in an increase in Pamp (P<0.001) and also a much smaller increase in Camp (P=0.03).

CONCLUSIONS: Monitoring the relationship between Camp and Pamp may help differentiate between compliance changes and increased Raw due to endotracheal tube secretions during HFOV. Pamp that changes inversely to Camp reflects Raw changes which may determine the appropriateness of endotracheal suctioning. Camp that remains unchanged or changes directly in relationship to Pamp indicates a change in compliance.

OF-99-136

INACCURACIES IN CO_2 MEASUREMENTS OF THE i-STAT BLOOD GAS ANALYZER WHEN COMPARED TO THE AVL OMNI BLOOD GAS ANALYZER

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Introduction: We report inaccuracies in $PaCO_2$ using the i-STAT Portable Clinical Analyzer with Thermal Control (i-STAT Corp. East Windsor, NJ). During routine weekly comparisons of i-STAT vs. AVL Omni blood gas instrument (AVL Scientific Corp. Roswell, GA), the i-STAT value for $PaCO_2$ was 20 mmHg lower than the AVL Omni value. In the previous month, a $PaCO_2$ discrepancy of 15 mmHg occurred. In both instances, commercial liquid controls performed on the i-STAT were within the accepted range. Because of these discrepancies, we performed a number of i-STAT vs. AVL comparisons in order to determine the extent of the problem.

Methods: First, three levels of liquid controls were performed on all instruments. Then 1.5 - 2.5 ml of blood was drawn from 11 critically ill patients using the SIMS line draw sampling kit (Part # 4043W-2, SIMS Portex, Keene, NH). Analysis of the sample was performed on the AVL Omni, AVL 995, and two i-STAT instruments providing 4 separate measurements for each sample.

Results: Liquid controls performed on all instruments were within the manufacturers acceptable range. In 3 of 11 patient samples (6 of 22 i-STAT vs. Omni comparisons), the i-STAT $PaCO_2$ was > 5 mmHg lower than the AVL with a maximum variance of 11.6 mmHg.

AVL 995		AVL Omni		i-STAT #1		i-STAT vs Omni		i-STAT #2		i-STAT vs Omni	
pH	PCO_2	pH	PCO_2	pH	PCO_2	Δ pH	ΔPCO_2	pH	PCO_2	Δ pH	ΔPCO_2
—	—	7.246	48.4	7.236	49.8	-0.010	1.4	7.227	50.9	-0.019	2.5
7.239	53.7	7.278	50.0	7.275	52.8	-0.003	2.8	7.273	53.2	-0.005	3.2
7.222	51.6	7.243	50.1	7.269	50.5	0.026	0.4	7.272	51.8	0.029	1.7
QNS	49.4	7.251	47.3	7.258	48.8	0.007	1.5	7.256	50.2	0.005	2.9
7.165	48.2	7.211	45.6	7.202	37.7	-0.009	**-7.9**	7.213	35.0	0.002	**-10.6**
7.254	34.9	7.292	32.9	7.267	23.4	-0.025	**-9.5**	7.278	25.2	-0.014	**-7.7**
7.357	33.3	7.380	32.4	7.385	20.8	0.005	**-11.6**	7.376	22.5	-0.004	**-9.9**
7.269	47.6	7.311	45.0	7.322	45.2	0.011	0.2	7.318	45.7	0.007	0.7
7.380	47.8	7.403	45.4	7.427	41.1	0.024	-4.3	7.427	42.8	0.024	-2.6
7.416	36.5	7.433	35.6	7.412	32.4	-0.021	-3.2	7.457	32.7	0.024	-2.9
7.318	51.2	7.349	50.4	7.345	46.0	-0.004	-4.4	7.352	47.3	0.003	-3.1

AVL 995 vs. AVL Omni - Mean (STD) differences for PCO2 = 2.0 (0.9). pH = –0.031 (0.011).
AVL Omni vs. i-STAT - Mean (STD) differences for PCO2 = -2.7 (4.9). pH = 0.002 (0.016).

These discrepant results were reported to i-STAT and the FDA. i-STAT use was discontinued at our institution. Representatives from i-STAT performed similar tests and also observed sporadic discrepancies. i-STAT worked cooperatively with SIMS Portex for three months to investigate this problem. In February 1999, i-STAT and SIMS Portex issued technical bulletins advising that an incompatibility existed between SIMS Line Draw syringes with dry lithium heparin and the i-STAT PCO2 measurement method (see i-STAT Technical Bulliten # 151665).

Conclusions: In our situation, recurrent inaccuracies in point of care ABG values would have escaped detection if we had relied solely on liquid controls to determine measurement precision, accuracy, and validity. Our experience has convincingly demonstrated the necessity of including real clinical specimens (either split sample intermethod patient specimens or tonometered whole blood) for point of care blood gas testing quality assurance programs.

OF-99-151

ACCURACY OF PULSE OXIMETERS DURING NEONATAL MOTION.

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Background: Pulse oximetry has been used for over a decade in the NICU as an indicator of pulse rate (PR) and oxygen saturation (SpO_2) of arterial blood. However, the validity of PR and SpO_2 readings are often suspect during motion. Masimo SET pulse oximetry (Masimo Corp, Irvine, CA) claims to measure during motion conditions as well as low perfusion. Nellcor Puritan Bennett (Pleasanton, CA) makes a similar claim with Oxismart technology (e.g., N-295) but not with their N-200 pulse oximeters. **Methods:** Sensors from a Masimo SET and a N-295 pulse oximeter were attached to opposing feet of an infant, whose feet were secured to a motion generator. The motion generator provided neonatal movement and was configured to simulate a kicking infant in frequency and amplitude. An additional pulse oximeter (N-200) was attached to the infant's right hand, which served as a stationary reference site (i.e., not exposed to the motion generator). Data (ECG heart rate, PR and SpO_2) were collected every second (1 Hz) by a computerized data acquisition (DAQ) system. A blood specimen (ABG) was drawn after 30 to 120 seconds of motion. The ABG draw time was noted in the DAQ file. The sensors were switched between feet and another ABG obtained after 30 - 120 seconds of applied motion. An AVL OMNI (AVL List GmbH Medizintechnik. Graz, Austria) was used for ABG analysis of pH, PCO_2, PO_2, total Hb, %COHb, %MetHb, and functional $\%SaO_2$. The bias and precision of PR versus the ECG monitor heart rate and SpO_2 versus functional $\%SaO_2$ were calculated. **Results:** 122 ABG and DAQ samples were analyzed from 14 newborns: gestation of 22 - 40 weeks and weight of 495 - 4100 gms. Ten zero outs (SpO_2 display of 0 %) and one outlier > 6Σ were excluded from the calculations [N-295 (8), N-200 (2), and Masimo (1)]. The heart rate (via ECG monitor) ranged from 83 to 200 bpm. The ranges of ABG values were: pH of 7.20 to 7.55, PCO_2 of 22.0 to 63.6 mmHg, PO_2 of 44.4 to 111.6 mmHg, total Hb of 9.4 to 17.3, COHb of 0.0 to 4.2 %, MetHb of 0.8 to 2.6%, and SaO_2 of 82.7 to 95.8 %.

Oximeter	**PR** [bias] (precision)	**SpO_2** [bias] (precision)
Masimo SET motion - foot	-0.1 (± 3.0)	-0.9 (± 2.3)
N-295 motion - foot	-3.4 (± 18.0)	+5.1 (± 8.1)
N-200 non-motion - hand	+5.2 (± 20.9)	+0.3 (± 4.6)

Discussion: Most pulse oximeter manufacturers state a precision for pulse rate of ± 3 bpm and a precision for SpO_2 of ± 3 % (at a bias of 0) in neonates during non-motion conditions. However, motion is common in this population. **Conclusions:** Motion adversely affects

OF-99-162

ANALYSIS OF PULSE OXIMETERS FOR DETECTION OF SPO_2 AND PULSE RATE VARIATION DURING MOTION ARTIFACT. G. B. Russell, MD, H. G. Schuler, CCRC, J. M. Graybeal, CRT*, Penn State University Dept of Anesthesia, Hershey Pa, and * Masimo Corp, Irvine Ca.
BACKGROUND: Pulse oximeters (PO) have frequent SpO_2 and pulse rate (PR) false alarms due to artifact conditions. New generation PO incorporate various technologies to minimize false alarms. Simulators, such as the Biotek Index 2p, have been developed which produce standardized PO artifact signals. We tested the hypothesis: POs will accurately report SpO_2 and PR during simulated motion artifact. METHODS: Using this simulator, set for no-motion (n) and 2 different motion artifacts (low frequency (lf) and high frequency (hf)), 11 POs were tested from SpO_2 70-98% and PR 45-180 bpm. POs tested included Nellcor Puritan Bennett N200 and NPB 295, Datex Ohmeda 3700, 3900, and AS/3, Hewlett-Packard model 66, Criticare Poni, Novametrix Oxypleth, Nonin 8600, BCI 3304 and Masimo SET. Results are presented as the bias +/- precision and number of failures to report. RESULTS: Agreement varied considerably between PO models. For SpO_2 the 3700 and AS/3 had bias >5% at n. All POs, except the Masimo SET, had bias >9% at lf and hf. For PR, at n, all POs were accurate within 1+/-1 bpm. All POs, except the AS/3 and Masimo SET, had bias > 50 bpm (PR > 50 bpm higher than set simulator PR) at both lf and hf. 6 POs, including the N200, N295, AS/3, Poni, Oxypleth, BCI 3304 and Nonin 8600 had multiple SpO_2 and PR failures during lf and hf. CONCLUSIONS: The Masimo SET was the only pulse oximeter able to accurately report both SpO_2 and PR during motion artifact.

Table
SpO_2 bias and precision (Prec) for all oximeters tested at no motion (n) and both low frequency (lf) and high frequency (hf) motion artifacts.

	No Motion			Motion lf			Motinn hf		
OXIMETER	Bias	Prec	Fails	Bias	Prec	Fails	Bias	Prec	Fails
N200	-1	1	0	-24	5	0	-28	6	1
N295	-1	1	0	-18	6	1	-22	4	2
3700	-6	3	0	-29	4	0	-31	5	0
3900	0	1	0	-17	5	0	-17	4	0
AS-3	-8	5	0	-23	6	0	-18	6	1
HP-66	-1	1	0	-27	7	0	-	-	10
PONI	-3	1	0	-25	3	0	-12	14	1
Oxypleth	-1	1	0	-9	9	2	-	-	10
BCI 3304	-1	1	0	-21	4	0	-	-	10
Nonin 8600	0	2	0	-15	7	0	-	-	10
Masimo SET	0	1	0	1	1	0	0	1	0

OF-99-171

Evaluation of Rapid Shallow Breathing Index (RSBI) as a Weaning Predictor in the Cardiovascular Recovery Room Utilizing a CO2SMOS+ Respiratory Profile Monitor

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Study Question: Can the Rapid Shallow Breathing Index (RSBI) be used as a reliable predictor of successful ventilator weaning and be incorporated into protocol in patients following cardiovascular surgery? This index is calculated by dividing the frequency (respiratory rate) by the tidal volume (VT) in liters. A value of <100 predicts successful weaning and a value of >100 predicts failure to wean. The CO2SMOS+ Respiratory Profile Monitor (Novametrix Medical Systems, Wallingford, CT) Ventilation Monitor calculates RSBI as one of its parameters. Through a collaborative effort between Respiratory Care, Nursing, and CV Anesthesia, a ventilator weaning protocol has been the standard of care since 1988. The surgical groups included in the protocol are Coronary Artery Bypass (CAB), Aortic Valve Replacement (AVR), Mitral Valve Replacement (MVR) and Abdominal Aortic Aneurysm (AAA). All patients are protocol eligible unless they are on a balloon-pump, Left or Right Vascular Assistive Device (LVAD/RVAD). Decision making algorithms are used to ensure consistency of protocol implementation. The protocol has initial ventilator set-up parameters. Mechanical ventilatory interventions include SIMV, pressure support (PS) and CPAP. The 4 stage protocol includes assessment criteria and associated clinical interventions. The fourth stage utilizes traditional weaning mechanics to evaluate for extubation. Patients must have a Negative Inspiratory Force (NIF) of >25cmH20, VT 5-7 cc/kg, and a VC 12-15 cc/kg and normal arterial blood gases (ABG's). **Method:** RSBI was evaluated to determine if it could be used to replace or be an adjunct to traditional ventilation weaning predictors. An initial study group of 10 patients was selected to determine if further study was justified. The surgical procedure in the study group was Coronary Artery Bypass (CAB). The CO2SMOS+ was used to calculate RSBI. Clinical outcome evaluation was accomplished by successful weaning prediction utilizing RSBI and reintubation rates within 24 hours. **RESULTS:** Analysis demonstrated the following. All patients met the traditional weaning parameters. An RSBI average was 60.67 with a range of 11-117. The reintubation rate of 0% (Total population divided by reintubated population). **Conclusions:** In cardiovascular patients the use of RSBI can indicate successful weaning without reintubation within 24 hours. The RSBI calculated by the CO2SMOS+ was clinically acceptable. Further investigation is warranted to determine if RSBI could replace or be an adjunct to traditional extubation predictors in the cardiovascular ventilation weaning protocol.

OF-99-173

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ASSESSMENT OF POLYMERASE CHAIN REACTION AND SEROLOGY FOR DETECTION OF *CHLAMYDIA PNEUMONIAE* IN THE PATIENTS WITH ACUTE RESPIRATORY TRACT INFECTION. SHI Yi, XIA Xirong, SONG Yong, KANG Xiaoming, FENG Genbao, HU Lanping. Department of Respirology, Jinling Hospital, Medical college of Nanjing University, Nanjing, 210002, P.R.China. Objective: To find out the infection rate and the clinical features of patients with acute respiratory infection caused by *Chlamydia pneumoniae*(*C. Pneumoniae*). Method: A prospective study for *C.pneumoniae* infection was conducted in 110 patients with respiratory tract infection from January-December 1995 in Nanjing. Sputum and throat swab specimens were taken and *C. pneumoniae* DNA were detected by polymerase chain reaction (PCR) with the HM-1-HR -I primer pair. At the same time, serum samples were taken and immunoglobulins G and M (IgG and IgM) fractions of antibodies to *C. pneumoniae* were studied by microimmuno-fluorescence test. Results: Prevalence of specific IgG was 70% in patients with respiratory tract infection. Seventeen patients (16%) were serologically diagnosed as having recent *C. pneumoniae* infection and 12 patients (11%) had the positive PCR in sputum and/or swab specimens. The total positive rate was 23% (25/110) combining PCR with serology. Acute infection of *C. pneumoniae* was common in the patients with asthma (57%), pneumonia (35%), COPD (26%) and bronchitis (25%). The clinical feature between *C. pneumoniae* infection and non-*C.pneumoniae* infection was that there was no significant difference. Conclusion: Our data suggest that *Chlamydia pneumonia* is an important pathogen that causes infections of the human respiratory tract and attention should be drawn to this special illness.

OF-99-241

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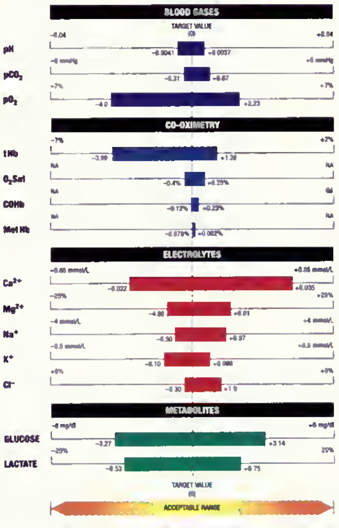

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NEWBORN NEONATE WITH SEVERE MEDIASTINAL SHIFT AND RESPIRATORY DISTRESS

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Background: In this case study we describe the unusual radiographic presentation of a 36 week gestation female, who developed almost immediate respiratory distress after delivery. In working through the differential diagnosis for mediastinal shift in a newborn, we found the cause was a rather rare congenital lung malformation.
Case summary: The infant was born to a 25 year old Gravida1, Para 1. The pregnancy was complicated only by gestational diabetes which was controlled by diet. A routine ultrasound was completed at 17 weeks gestation and showed no fetal abnormalities. The child was born via spontaneous vaginal delivery with Apgars of 4,6 and 7 at 1,5 and 10 minutes respectively. Upon arrival of the transport team, the patient was in 100% FIO_2 with an oxygen saturation level of 78%. The infant was very dusky and quickly desaturated to 60% with any stimulation. Breath sounds were diminished and best heard over the right axilla and left upper lobe. The patient was intubated and intravenous access obtained. A chest radiograph was obtained and showed a marked shift of the heart to the right with tracheal deviation and opacification of the left lung except for the left upper lobe. An initial arterial blood gas revealed a PaO_2 of 40, PCO_2 of 60 and a Ph of 7.28. The patient was placed on a Biomed MPV 100 with an IMV rate of 50, ventilating pressures of 24/4 and FIO_2 initially of 100%. The patient was transported without incident. A chest and abdominal ultrasound was obtained and was suggestive of a left sided diaphragmatic hernia. A CT scan was then performed to help confirm the diagnosis. The CT scan showed an extensive compression of the lung parenchyma and mediastinal shift by a solid appearing mass consistent with a Type III Congenital Cystic Adenomatoid Malformation (CCAM). Several days later, the patient was taken to the operating suite for resection of the CCAM. A mass measuring 7.6 X 6 X 4 cm was removed and was confirmed on pathology report as a type III CCAM. Postoperatively the patient had two incidences of recurrent airleak requiring chest tube management. Three days postoperatively, the patient was extubated to room air and two weeks later was discharged to home.
Conclusion: While CCAM is a rare malformation, it represents 25% of all congenital lung malformations. The type III CCAM illustrated in this case is extremely rare as it comprises only 10% of all diagnosed cases. Health care providers who work newborns and children, especially those involved in transport need to be aware of this congenital malformation.This case further highlights the difficulty which may be encountered in establishing a diagnosis. This pathology needs to be considered in cases of mediastinal shift in the newborn.

OF-99-003

DO HEALTHY PRETERM INFANTS MAINTAIN RESPIRATORY STABILITY IN CAR SAFETY SEATS?

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Introduction: There is little data on respiratory stability in car seats of healthy preterm (PT) infants, not requiring NICU care. The purpose of this study was to evaluate these healthy PT infants as compared to a control group of term (T) infants. Methods: Infants were recruited from the newborn nursery. PT infants were 35-36 weeks using best obstetrical criteria for dates. Controls were ≥37 weeks using the same criteria. Parents' car seats were used unless the car seat did not meet current safety standards or dimensions were not suitable for a newborn. Edentec Assurance 2000 apnea monitors with memory and Nellcor N3000 pulse oximeters were used. Baseline values were obtained with infants positioned supine for 30 minutes, they were then placed in their car seat with supporting blanket rolls for an additional 90 minutes. Significant events were defined as apnea >20 seconds, bradycardia < 80 bpm for ≥ 4 seconds, or desaturation <85% for ≥ 4 seconds. Results: Twenty-six infants were evaluated (13 PT and 13 T). Mean birthweight (BW) for the PT infants was 2520 ± 486g and 3437 ± 1048g for controls. Mean postnatal age was 3.8 ± 1.7 days (range 1-7) for PT infants and 2.6 ± 1.7 days (range 1-7) for controls. Eighteen percent of car seats furnished by parents were unacceptable. Six of 13 PT and 2 of 13 T infants met criteria for significant events in their car seats (p=0.08). All events were self-limited except for one PT infant, who required stimulation and was subsequently admitted to the NICU. No controls had apnea or bradycardia. Five infants (2 PT and 3 T) spent >25% of the time in the car seat with oxygen saturations < 90%. Both PT and T infants experienced a decrease in oxygen saturation in their car seats (TABLE).

O2 Saturations	%time at sat value BASELINE	%time at sat value CAR SEAT	p-value
95-100%	79.5	54	0.0004
90-94%	20.5	36.5	0.0099
85-89%	0	9	0.013
<85%	0	0.5	0.018

Conclusions: Preliminary data suggests that even healthy, PT infants are at risk for respiratory instability in their car seats. However, both PT and T infants are equally susceptible to decreased oxygen saturations in their car seats.

OF-99-024

WEANING TO EXTUBATION DIRECTLY FROM HIGH FREQUENCY OSCILLATORY VENTILATION (HFOV) IN AN INFANT WITH CYSTIC LUNG DISEASE AND PERSISTENT AIR LEAK: A STRATEGY FOR LUNG PROTECTION

Lori Seller RRT, Krishna Mullahoo RRT, Stephen Liben MD, Larry C. Lands MD, PhD. Montreal Children's Hospital, Montreal, Quebec, Canada.

Introduction: HFOV is generally used in the acute stage of respiratory failure, providing a lung protective strategy while maximizing gas exchange. Typically, patients are weaned from HFOV to conventional ventilation (CV) and progress to extubation. We report the successful weaning and extubation from a SensorMedics 3100A high frequency oscillator without returning to CV in a infant with respiratory syncytial virus (RSV) bronchiolitis, complicated by cystic pulmonary lesions and recurrent pneumothoraces.
Case study: A 7 week old term infant with severe RSV bronchiolitis, was ventilated on pressure regulated volume control mode (Siemens 300; f = 38 breaths/minute, V_T = 10 mL/kg, Pressure = 33/7 cmH_2O, FiO_2 = 0.50) for 5 days. Due to persistent collapse and decreasing lung volumes on the chest x-ray (CXR), as well as increasing oxygen needs, HFOV with inhaled nitric oxide was started on day 6. On day 8, cystic structures became apparent on CXR. As the RSV infection abated, attempts to switch the patient back to CV for weaning failed due to recurrent pneumothoraces. A computed tomography (CT) of the chest revealed multiple, well defined cysts of varying sizes involving both lungs. These results ruled out any surgical or unilateral ventilation options due to the bilateral and multifocal nature of the cysts. Weaning to extubation from HFOV was proposed as a possible way of preventing further air leak. The patient was then stabilized on HFOV for 12 days with the use of a minimal mean airway pressure (MAP) of 9 cmH_2O, during which time the air leak resolved. Sedation was weaned to allow spontaneous breathing. A weaning schedule was started whereby the patient was "sprinted" by decreasing the amplitude (ΔP) from 30 to 10 cmH_2O and the MAP from 9 to 7 cmH_2O for twenty minutes three times a day. The frequency and duration of the "sprints" were gradually increased, eventually stopping oscillation (Δ P) while maintaining a continuous positive airway pressure (CPAP) or MAP of 7 cmH_2O for the "sprinting" period. On day 39, the patient was successfully extubated directly from HFOV with no complications. A follow up CT of the chest showed marked improvement in the size of the cystic lesions. The patient was discharged home 10 days later with no need for home oxygen therapy, and an almost normal CXR.
Discussion: Most reports of extubation directly from HFOV involve the premature, neonatal population. Effective tidal breathing adequate to maintain normocapnia can be achieved by the pediatric patient on HFOV by decreasing the MAP, and the ΔP to the point of minimal or no oscillation. Weaning directly to CPAP from HFOV may be a feasible option for patients requiring a protective lung strategy throughout the weaning stage.

OF-99-019

ASSESSMENT AND APPLICATION OF THE AMERICAN SOCIETY OF ANESTHESIOLOGISTS DIFFICULT AIRWAY ALGORITHM IN THE PEDIATRIC POPULATION

Roberta L. Hales, BS, RRT, P/P Spec., Andrew Costarino, MD, Samuel Yanofsky, MD, The Children's Hospital of Philadelphia, Philadelphia, PA

Background: Differences in anatomy between the adult and child larynx challenge the practitioner to utilize variable techniques in order to successfully intubate the pediatric patient. Because no pediatric airway algorithm exists, we evaluated the adult American Society of Anesthesiologists (ASA) Difficult Airway Algorithm[1] for use with children. Use of Laryngeal Mask Airways (LMA) and flexible fiberoptic bronchoscope are recommendations within the Difficult Airway Algorithm. These findings, along with the availability of smaller sizes of these instruments, inspired us to incorporate them into our practice, for use by Critical Care Medicine/Anesthesia physicians in the Pediatric Intensive Care Unit (PICU). An airway assessment tool was developed in order to identify those pediatric patients who were considered to have a difficult airway and may therefore require the use of these instruments. Respiratory Care Practitioners (RCP's) were educated to assist Critical Care Medicine/Anesthesia with the implementation of the LMA.
Method: Data was collected on all patients requiring intubation in the PICU and Operating Room. Patient history, diagnosis, prior intubations, airway assessment, including the Mallampati Score (>3 years of age)[2], the anterior mandibular space-thyromental distance, dental exam, oropharnygeal-nasopharnygeal exam, and c-spine immobilization were included in the data collection. In addition, data was collected regarding ventilation technique prior to intubation, level of training of personnel, complications of airway management, and intubation procedure including: patient's level of consciousness, instrumentation used, number of attempts, cricoid pressure and size and type of airway placed.

Successful Intubations	Class I & II (easy) Mallampati Score	Class III & IV (difficult) Mallampati Score
1 Attempt	91 (86%) *	4 (4%) *
Multiple Attempts	6 (6%)	4 (4%) *

n = 105

* The airway assessment tool was successfully used in classifying and evaluating 94% of the patients.

Conclusions and Recommendations: The pilot use of this pediatric airway assessment tool enhanced our ability to identify patients at risk for difficult airway management. It identified a potential need for the use of LMA's and flexible bronchoscope to facilitate successful intubation. Continuing data collection and further evaluation is needed to validate the use of a pediatric-based algorithm and develop a composite scoring system for early identification of high-risk patients.

1. American Society of Anesthesiologists Task Force. Practice Guidelines for Management of the Difficult Airway. Anesthesiology 1993; 78(3): 597-602.
2. Stoelting, RK, Miller RD: Basics of Anesthesia 3rd ed. New York, Churchill Livingstone, 1994, pp145-162.

OF-99-048

UTILIZING KINETIC AND PERCUSSIVE THERAPIES TO IMPROVE PULMONARY OUTCOMES OF A PEDIATRIC PATIENT: A Case Study.

Theresa Ryan Schultz, BA, RRT, CPFT, P/P Spec., Roberta Hales, BS, RRT, P/P Spec., Ann Marie Wallack, AS, RRT, P/P Spec., Kathleen Sloan, BS, RRT, P/P Spec., Denise Garvey, AS, CRT, P/P Spec., Mark Helfaer, MD. The Children's Hospital of Philadelphia, Philadelphia, PA.

A 5 mos. old with a history of Hemophagocytic Syndrome was admitted to the PICU in respiratory distress requiring 60% oxygen via tent. She was tachypneic with a respiratory rate of 145, and tachycardic to 176. Within two days of this ICU admission, the patient became acidotic and hypoxic, requiring nasal tracheal intubation. PaO_2/FiO_2 (P/F) one hour post intubation and mechanical ventilation was 64. This patient received a Bone Marrow Transplant on the third day of this ICU admission. After eleven days of mechanical ventilation, the patient was weaned to extubation. Negative inspiratory force was -50 cm H_20 prior to this brief trial. This patient was re-intubated with 3.5 mm tracheal tube secondary to extrathoracic gasway obstruction. One day post re-intubation this patient's P/F remained <250 (233). She progressively deteriorated over the next few days requiring volume replacement for hemodynamic instability. Chest x-ray eventually revealed worsening of fluffy infiltrates/nodules. Follow-up CT Scan showed complete atelectasis of the left lung with mediastinal shift towards the left and right scattered pulmonary nodules. Amphotericin was started for a presumed fungal infection. Fluids and dopamine were administered for continued periods of cardiovascular instability. Pulmonary toilet with manual bilateral rotation and percussion followed by suction was done every 2-4 hours. In spite of these efforts this patient's P/F fell to 183 over the next few days. It was decided that this patient might benefit from the kinetic and percussive therapies available on the KCI PediDyne Crib[1]. The patient was transitioned to this crib without incident. Continuous lateral rotation/kinetic therapy @ 30-40 degrees with percussion every 4 hours were the therapies utilized. Within twenty-four hours of receiving these therapies, the patient's P/F increased to 209. There were no other changes in ventilating pressures or minute ventilation. Within 72 hours of initiating therapy, this patient's P/F increased to 251. By the 90th hour of therapy, the P/F increased to 366. The patient then began to wean from the mechanical ventilator and was successfully extubated to a 2 liters per minute nasal cannula 4 days later. Chest radiograph showed no focal radiodensities at this point in time. She was transferred out of the ICU one day after successful extubation.

Day of mechanical ventilation	Therapy	PaO_2/FiO_2	% change
11	–	Failed extubation	–
15	manual rotation/percussion	183	–
15	Kinetic therapy started	–	–
16	Kinetic therapy/percussion	209	12%
18	Kinetic therapy/percussion	260	30%
19	Kinetic therapy/percussion	366	50%
23	Kinetic therapy/percussion	Successful extubation	–

Conclusion: Kinetic and Percussive Therapies available on the PediDyne Crib seemed to be a valuable adjunct to this patient's course of treatment. For these reasons, we have developed a prospective crossover design study to investigate this objectively.

1. McKay C. A Supplement to RN. Best Practices: Reducing nosocomial pneumonia. Feb. 1999.

OF-99-049

NITRIC OXIDE AND SURFACTANT REPLACEMENT IN PEDIATRIC ACUTE RESPIRATORY DISTRESS SYNDROME: A CASE REVIEW.

Shawn Colborn, AS, RRT, Angela Mittman, AS, RRT, P/P Spec., Lorraine F. Hough, MEd, RRT, CPFT, P/P Spec., Margaret Priestly, MD, Theresa Ryan Schultz, BA, RRT, CPFT, P/P Spec., The Children's Hospital of Philadelphia, Philadelphia, PA.

Introduction: This is a 2 year old female whose past medical history includes tracheostomy, secondary to trachiobronchomalacia, and reactive airways disease with new onset bronchiolitis/respiratory failure. She was admitted to our Pediatric Intensive Care Unit from an outlying institution where she had been decannulated, intubated and mechanically ventilated for thirty-six hours. Persistent hypercarbia and hypoxemia with ground glass appearance on chest roentgenogram were reported. Upon arrival, her ventilatory requirement of 189 cc/kg/min. corrected exhaled minute ventilation, PEEP 15 cm H_2O, PIP 37 cm H_2O and FiO_2 1.0 yielded the following: pH 7.28, $PaCO_2$ 67.5, PaO_2 77.5, HCO_3 36.3, B.E. 10.3, PaO_2/FiO_2 (P/F) 78, Oxygenation Index (OI) 30. A cuffed endotracheal tube was later placed, due to continued leakage around the uncuffed tube. Methods: During this admission, a multitude of interventions were trialed including terbutaline, versed, fentanyl and pavulon infusions, solumedrol, zantac, lasix, inhaled nitric oxide (NO) and Survanta administration via direct instillation. Results: This graph shows varied responses to inhaled nitric oxide pre and post Survanta delivery with no other changes in patient intervention.

Nitric oxide *pre* Survanta administration	**P/F**	**% change**	**OI**	**% change**
Admission (day 2 of mechanical ventilation-MV)	78	-	30	-
1 hr. into 1st NO trial (day 3 of MV)	72	No response	31	-
2 hrs. into 1st NO trial (day 3 of MV)	60	No response	37	-
6 hrs. into 1st NO trial	60	No response	35	-
(discontinued on day 3 of MV)				
Survanta administration	**P/F**	**% change**	**OI**	**% change**
Pre surfactant administration (day 5 of MV)	71	-	37	-
Post surfactant administration (day 6 of MV)	72	No change	35	5%
Nitric oxide *post* Survanta administration	**PF**	**% change**	**OI**	**% change**
1 hr. into 2nd nitric oxide trial (day 6 of MV)	97	**27%***	26	**30%***
4 hrs. into 2nd nitric oxide trial (day 6 of MV)	97	**27%***	26	**30%***
8 hrs. into 2nd nitric oxide trial (day 6 of MV)	90	**21%***	27	**27%***
13 hrs. into 2nd nitric oxide trial (day 6 of MV)	98	**28%***	22	**41%***

*(20% change in the P/F or OI is considered a favorable response)

Conclusions: Upon review of this patient's course of illness and response to therapeutic interventions, it seems inhaled nitric oxide after Survanta administration yielded a more favorable response than nitric oxide alone or Survanta alone.

OF-99-054

MECHANICAL VENTILATION WEANING PROTOCOLS IN CHILDREN: A PILOT STUDY.

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Introduction: Mechanical ventilation remains a critical component in the management of respiratory insufficiency. Weaning from mechanical ventilation accounts for as much as 40% of the time a patient receives mechanical ventilation.[1] Traditionally, this process has required the physicians presence to strategically manage and monitor the patient's response to the reduction of ventilatory support. A patient's recovery of respiratory function, either from resolution of the patient's illness or a reduction in anesthetic effects in post-operative patients, is often unpredictable. With other clinical responsibilities, the physician may not be available at such times. Delays in weaning from mechanical ventilation may lead to unnecessary discomfort in the intubated patient. Increased risk of complications related to tracheal intubation and mechanical ventilation such as tracheitis, volu/barotrauma, subglotic stenosis, and vocal cord paralysis may occur. We hypothesize that a protocol-directed weaning strategy results in a decrease in total mechanical ventilation time with no increase in morbidity when compared to physician-directed weaning of pediatric patients. **Methods:** This was a prospective, randomized control trial. Patients were randomized to one of two groups at the onset of mechanical ventilation or upon admission to our Intensive Care Unit if mechanical ventilation was initiated prior to admission. Protocol-directed (study) and physician-directed (control) patients were recruited from the pediatric intensive care unit and cardiac intensive care unit. Patients were enrolled if they received mechanical ventilation via tracheal intubation at any time during their intensive care unit hospitalization. Initiation of weaning began when: $FiO_2 < 0.6$, PEEP < 8 cm H_20, total (patient + ventilator) respiratory rate (RR) < 1.5 x predicted value for age using the mean value, ratio of actual V_E to predicted $V_E > 2$, pH > 7.35 when available, and $Sp0_2$ was within normal limits as established for that patient. Criteria for beginning weaning also included maximum inspiratory force -20 cm H_20, and spontaneous initiation of breath for ten consecutive minutes. When these criteria were met, the Respiratory Care Practitioner reduced the amount of pressure support administered to the least level of pressure support necessary to maintain the patient's RR less than or equal to 1.5 times the mean predicted RR for age. The study endpoint was reached when pressure support was ≤ 5 cm H_20 with PEEP ≤ 5 cm H_20. Exclusion criteria included hyperventilation of head-injured patients and marginal cardiac function. **Results:** 55 patients have been enrolled to date: 30 male, 25 female. Age in years averaged 6.7. 12 hour Prism III scores averaged 5.7 +/- 5 for study patients and 7.4 +/- 6.1 for control patients. 24 hour Prism III scores averaged 6.7 +/- 5.4 for study patients and 8.3 +/- 7.4 for control patients. Prism III at 12 and 24 hours were not statistically significant between groups.

	Protocol-Directed	Physician-Directed
Time prior to weaning (hours)	58.5 +/- 115.9 (median=12)	122.5 +/- 249.3 (median=13)
Duration of weaning (hours) *	10.5 +/- 25.4	44.5 +/- 67.4
Duration of $FiO_2 > .4$ (hours)	2.6 +/- 4.2	34.9 +/- 163.6

represents mean data +/- standard deviation * indicates p-value < .05

Conclusions and Recommendations: Protocol-Directed weaning seemed to be valuable in the weaning of our ICU patients. Utilizing a protocol-directed plan of care can shorten weaning time.

1. Esteban A, Aslfa I., Ibanez J, Benito S, Tobin MJ: Spanish Lung Failure Collaborative Group. Modes of mechanical ventilation and weaning: a national survey of Spanish hospitals. Chest 1994:106: 1188-93.

OF-99-053

AIRWAY MANAGEMENT DURING PEDIATRIC BURN TRANSPORT

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Shriners Hospitals for Children-Cincinnati

One of the most challenging aspects of transporting pediatric burn patients is care of the artificial airway. Fixed wing services differ from helicopter transports in that responsibility for patient care encompasses a much longer time period. Continual assessment of the airway for patency as well as proper positioning is imperative.

One of the top priorities is securing the artificial airway in a way that will facilitate some movement while protecting the airway from dislodgment. A method that works well when the patient's face is burned involves securing the endotracheal tube with adhesive tape and surgical staples. Benzoin can also be applied to the face to help the tape adhere. Stretcher movement during the transport process poses a risk of inadvertent malposition of artificial airways.

One of the biggest challenges is ongoing swelling that occurs during burn shock resuscitation. This resuscitation period usually continues for 24 to 36 hours post burn. Facial swelling during this period may severely compromise the pediatric airway.

One millimeter of edema in the pediatric airway can severely compromise respiratory status. It's important to ensure early intubation before this edema formation blurs landmarks. Elective intubation at the referring hospital in a controlled environment is preferable to emergent intubation.

The tube should be resecured with tape end staples and measured before leaving the referring hospital. Measurements are repeated with every transfer of the stretcher to ensure position is maintained

Careful assessment of patient status includes obtaining arterial blood gases when the patient is initially placed on the transport ventilator and then hourly throughout flight. If ventilator changes are made or the patient's status changes. additional measurements are obtained.

Increased secretions as well as carbonateous deposits in the airway require aggressive suctioning throughout all phases of transport.

Obtaining a chest x-ray after the patient is transferred from the referring hospital's bed to the transport stretcher validates proper tube position and allows repositioning if appropriate. An evaluation of transport records found that 37% required repositioning following chest x-ray The correct position is two centimeters above the carina. Edema formation may affect tube placement as well as flexion or extension of the head.

Maintaining a patent airway and the proper position of the artificial airway is of primary concern during the transport of a burned child. An understanding of the pathophysiology of burn shock and the pediatric airway alerts the caregiver to potential issues and allows intervention before serious airway compromise develops

OF-99-073

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PILOT STUDY OF INTRAPULMONARY PERCUSSIVE VENTILATION FOR TREATMENT OF ATELECTASIS IN THE INTUBATED PEDIATRIC PATIENT

Kathleen Deakins RRT, Robert L. Chatburn, RRT, FAARC,
University Hospitals of Cleveland, OH

INTRODUCTION: Intrapulmonary Percussive Ventilation (IPV) is a therapeutic modality designed to promote mobilization and facilitate the removal of retained secretions, re-expand areas of collapse, increase deposition of aerosolized particles, and improve gas exchange. IPV is ordered routinely at our institution for treatment of atelectasis as an adjunct or alternative to conventional chest physiotherapy. However, there are no published clinical practice guidelines that would identify either clear indications or expected outcomes for this treatment. The purpose of this pilot study was to determine if IPV was associated with any objective evidence of clinical improvement.

METHODS: This retrospective study evaluated 46 pediatric patients in the pediatric intensive care unit, rehabilitation unit, and acute care areas from November 1996 through March 1999, who had radiographic evidence of atelectasis. Patients received IPV therapy (Intrapulmonary Percussionator Ventilator, IPV-1, F.M. Bird Corp) at frequencies of 180-220 cycles per minute at pressures of 15-30 cm H_20, using 2.5 mg Albuterol and 6 mL normal saline. Chest radiographs were evaluated by a pediatric radiologist prior to IPV therapy and after it was discontinued. The following scoring system was used: 4 = complete collapse of two or more segments or lobes, 3 = complete collapse of one segment or lobe, 2 = partial collapse of two or more segments or lobes, 1 = partial collapse of one or segment or lobe and, 0 = complete resolution of collapse. Differences in median values before and after treatment were compared with the Mann-Whitney Rank Sum Test with significance set at $p \leq 0.05$.

RESULTS: The median age of patients studied was 4.2 years (range 1 month to 15 years). Ninety percent of them had artificial airways, the rest had IPV delivered by mask. The median duration of IPV treatment was 6.2 days. There was a significant improvemant in radiology score from 3 to 1 ($p < 0.001$).

CONCLUSION: This pilot study has shown that IPV is associated with a significant and clinically important improvement in atelectasis. However, it is unclear whether IPV treatment altered the natural resolution of atelectasis. These data justify a further, controlled study comparing IPV with conventional chest physiotherapy.

OF-99-074

COMPARISON OF CONVENTIONAL CPT WITH INTRAPULMONARY PERCUSSIVE VENTILATION FOR TREATMENT OF ATELECTASIS IN THE INTUBATED PEDIATRIC PATIENT

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Robert L. Chatburn, RRT, FAARC, University Hospitals of Cleveland, OH

INTRODUCTION: Intrapulmonary Percussive Ventilation (IPV) is a therapy designed to re-expand areas of atelectasis, facilitate removal of secretions, increase aerosol particle deposition, and improve gas exchange. This study was a follow-up to our previous pilot data showing that IPV was associated with improvement in atelectasis. Our purpose was to test the hypothesis that IPV, when given via artificial airway, is superior to chest physiotherapy (CPT; clapping and vibration) in improving atelectasis and static compliance. **METHODS:** We enrolled 13 subjects from our Pediatric Intensive Care Unit who were intubated and mechanically ventilated and who had radiographic evidence of atelectasis. Atelectasis was quantified from routine chest radiographs by two blinded observers (radiologist and physician) using an ordinal scale as follows: 4 = complete collapse of two or more segments or lobes, 3 = complete collapse of one segment or lobe, 2 = partial collapse of two or more segments or lobes, 1 = partial collapse of one or segment or lobe and, 0 = complete resolution of collapse. Patients with fever or positive secretion cultures were excluded. Patients were randomized to conventional chest physiotherapy (CPT; clapping and vibration) or IPV (Intrapulmonary Percussionator Ventilator, IPV-1, F.M. Bird Corp). IPV treatments were given with 6 mL normal saline solution at 15-30 cm H_20 (equal to peak pressures on the ventilator) using frequencies of 180-220 cycles per minute. Both treatments were delivered every four hours and lasted about 10 minutes. Static compliance (pre and post treatment) was measured with a CO_2SMO+ (Novametrix Medical Systems Inc.) using an inspiratory hold to obtain plateau pressure during mechanical ventilation (using a Siemens Servo 900C) with tidal volumes of 6-10 mL/kg. Differences in median values were compared with the Mann-Whitney Rank Sum Test with significance set at $p \leq 0.05$. **RESULTS:** The median age of patients in the study was 3.1 years (range 1.5 months to 14 years). ET tube size ranged from 3.0 uncuffed to 7.0 cuffed, but 4.0 uncuffed was most common. The median duration of treatment for CPT was 7 days (range 4-8); median duration for IPV was 2.5 days (range 2-14). No side effects of either treatment were noted in any patient. Data below are reported as medians:

	CPT			IPV		
	Pre	Post	p	Pre	Post	p
Compliance (cm H_2O)	2.4	2.0	0.55	5.0	5.3	0.72
Atelectasis score	2.0	2.0	0.42	2.5	1.0	0.007

CONCLUSION: This controlled clinical trial has shown that IPV is associated with a significant and clinically important improvement in atelectasis, whereas conventional CPT is not. Neither treatment improved respiratory system compliance. IPV is a safe and effective method of airway clearance that can be used on patients with artificial airways and seems to be superior to conventional clapping and vibration.

OF-99-075

TRAIL'S EDGE CAMP FOR VENTILATOR DEPENDENT CHILDREN RESPIRATORY CARE PRACTITIONERS REACH OUT: A TEN YEAR EXPERIENCE

Mary Dekeon R.R.T, Elizabeth McCleary R. R. T., Ken Bandy R. R. T. University of Michigan Medical Center, Ann Arbor, Michigan

On June 6, 1990, 48 volunteers and 18 campers began the first camp for ventilator dependent children. Trail's Edge Camp was created as a suggestion by a parent of a ventilator dependent child. Exhausted from the rigors of caring for a medically fragile child, she felt desperate for a break. She described the need for a few days in which her son would have a good time and she and her husband would be relieved of the enormous challenges of his care. Touched by her plea, respiratory care practitioners and other medical professionals from the University of Michigan Center, under the guidance of the Pediatric Respiratory Care Department, spent the next ten months, fund raising, planning, and recruiting volunteers to make that plea a reality. That first session of Trail's Edge Camp far exceeded everyone's expectations. The families felt rejuvenated, campers had made new friends, experienced nature and had the time of their life, especially with the pranks. The medical professionals who volunteered shed tears when they said good bye and spoke of "next year". And so for the following nine years the fund raising, recruiting, and hours of planning and training have led to one successful year after another.

Over the decade the numbers have changed. This year 29 children attended camp with 90 volunteers. But the spirit and energy that flourished that first year continues. A tree, planted ten years ago to mark the event, has grown, and so have the campers, three will graduate from high school this year, several have already graduated, and one is in college. Emotionally and spiritually we have all grown together, bonded by a special magic, the magic of summer camp.

For the respiratory therapists who began Trail's Edge Camp, what started as a way to give, became the most rewarding facet of their career. We learned, as so many volunteers have learned, that you receive ten fold what you give. Our lives and our careers so much "richer" because of our camp experiences, experiences that have made us "barrier free".

OF-99-091

A Promethean Adjunct to Ventilating an Infant with Severe Tracheobronchomalacia Using Helium-Oxygen Mixtures: A Case Report.

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Introduction: There is scant information about the use of helium-oxygen mixtures (heliox) in the neonatal patient with chronic lung disease. We present a case report of a mechanically ventilated premature infant receiving heliox to reduce airway resistance secondary to tracheobronchomalacia. **Case summary:** A 27 week estimated gestational age, male infant, delivered via Cesarean section, required mechanical ventilation for respiratory distress. The infant was transferred to our neonatal intensive care unit at 30 days of age for patent ductus arteriosus ligation and ventilator management. Over the next eight months, the infant developed seizures, multiple episodes of sepsis, bronchopulmonary dysplasia with failure to wean from continuous mechanical ventilation. Severe tracheobronchomalacia was diagnosed by bronchoscopy. The patient had severe desaturations and ventilator asynchrony with agitation and airway collapse. Heliox gas therapy (F_IHe of 0.65) was initiated. There was an immediate and significant clinical improvement in ventilation with a decrease in $PaCO_2$ from 110 mmHg to 50 mmHg and an increase in pH from 7.17 to 7.47. The infant continued to receive heliox for five days. The intervention with heliox allowed the patient's blood gases and work of breathing to stabilize. **Discussion:** Mechanical ventilation of an infant with complex obstructive airway disease is a challenge. Tracheobronchomalacia is characterized by a decrease in airway tone and structure, which leads to airway obstruction. Heliox is effective in reducing the symptoms of upper and lower airway obstruction because of its low density and high kinematic viscosity. Both functions work to reduce the collapse of tracheal tissues and enhance carbon dioxide clearance. This case study suggests heliox is a viable bridge in the episodic, exacerbation of airway collapse in a mechanically ventilated infant with tracheobronchomalacia.

OF-99-132

EVALUATION OF VOLUME DELIVERY IN THE PEDIATRIC SETTING FOR TWO DUAL CONTROL MODES (DCM) OF VENTILATION IN THE PRESENCE OF INCREASINO ENDOTRACHEAL TUBE LEAK

Kenneth F. Watson MS RRT, Eman S. Al-Khadra MBBS, John E. Thompson RRT, John Arnold MD. Children's Hospital, Boston, MA

Background: We investigated the ability of two ventilators set to operate in a dual control mode (DCM) to maintain target tidal volumes in the face of increasing endotracheal tube leak.

Methods: We evaluated volume delivery of DCMs for two ventilators (Augmented Pressure Ventilation, Hamilton Galileo; Pressure Regulated Volume Control, Siemens Servo 300A) using a DB&M Products Infant Lung Simulator. Patient conditions were simulated by appropriately matching tidal volumes from 30 to 200 mL to endotracheal tube sizes from 3.5 to 5.5 mm ID. A lung/thorax compliance of 3 mL/cm H_2O was maintained. An adjustable valve was placed distal to the endotracheal tube to simulate leaks. Leaks in 5 per cent increments from 10 to 50 per cent were created. A heated wire pneumotach was placed between the ventilator and the endotracheal tube connection to measure leak percentage. Delivered and exhaled tidal volumes and minute vulumes proximal and distal to the leak were measured using a pressure differential pneumotach.

Results: We evaluated the actual value and percentage change in inspired and expired tidal volume and minute volume for each volume/weight, endotracheal tube size, and leak percentage for the two ventilators. P value was calculated for the decrease in expired minute volume measured distal to the leak at each leak increment. At delivered tidal volumes less than or equal to 60 mL, minute volume did not decrease significantly in either ventilator ($P \geq 0.05$) until leaks greater than or equal to 20 per cent were created. With delivered tidal volumes greater than 60 mL, minute volume did decrease significantly ($P \leq 0.05$) at leak percentages greater than 20 per cent. Therefore, proportionally larger decreases in expired minute ventilation were noted at larger tidal volumes at a given leak increment. Decreases in minute volume were greater in the Servo 300 than in the Galileo.

Conclusions: The two ventilators that we evaluated do not fully compensate for endotracheal tube leaks in their dual control modes. Although the decrease in volume loss to the patient is statistically significant, further investigation into its clinical significance is warranted.

OF-99-106

UNCUFFED ENDOTRACHEAL TUBES TO SCAVANGE ANESTHETIC EXPOSURE DURING CONTINOUS ISOFLURANE MECHANICAL VENTILATION, IN THE PICU,

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Introduction: Bronchodilator effects of inhalation anesthetics such as Isoflurane have been reported with improved peak inspiratory pressure and gas exchange. Mechanical ventilation with continuos Isoflurane for support of pediatric patients with reactive airway disease in a intensive care unit requires a closed ventilatory system. In our facility this is accomplished with an Federal Drug Administration (FDA) approved Servo 900C Anesthesia System (Siemens Medical System, Danvers, MA) and a cuffed endotracheal tube (ETT). However, pediatric patients are routinely intubated with uncuffed ETTs. We describe a simple adaptation to uncuffed ETT, to scavenge continuous Isoflurane, and avoid exchange with cuffed ETTs on unstable reactive airway disease patients. **Case Summary:** CT is a nine month old African American male with a past medical history of mechanical ventilation at birth, and bronchopulmonary dyspalsia. CT was electively intubated, at the sending hospital, for a herniorrhaphy, with an uncuffed 3.5mm ETT and transported to our Pediatric Intensive Care Unit (PICU) for treatment of post-obstructive pulmonary edema, reactive airway disease. He required mechanical ventilation and aggressive management of wheezing with continuous delivery of Isoflurane over a 39-hour period before transitioning to conventional ventilation and subsequent extubation. As CT's airway edema resolved he developed an increased air leak around the uncuffed ETT resulting in a proportional leak of Isoflurane into his room and concern of anesthesia exposure to his assigned health care providers. The use of Isoflurane over 39 hours involved approximately 9 hours on pressure control ventilation (PCV) and 30 hours on volume control ventilation. Tidal volume loss is reported as inhaled vs exhaled minute ventilation (VE) and the patient's normalizing End Tidal Carbon Dioxide (ETCO2) levels support improvement.

Date	Time	Mode	Deliv. Ve**	Exhal.Ve**	% leak	RRset/act	% ISOF.
3/11/99	1650	PCV	N/A	2.32	N/A	25/25	1
3/12/99	730	SIMV/PSV	3	2.26	25%	25/25	0.9
3/12/99*	1940	SIMV/PSV	3	2.4	20%	25/25	0.3
3/13/99	30	SIMV/PSV	3	2.5	17%	25/25	0.3
3/13/99	400	SIMV/PSV	3	2.1	30%	25/25	0.3
3/13/99	745	SIMV/PSV	3	2	33%	25/25	0.28

* endoscopy mask applied   ** liters/min

We employed, unsuccessfully, several pieces of equipment to scavenge the Isoflurane leaking from CT's ETT including a care cube (MES, Burbank, CA) and an adult simple mask (Allegiance, McGaw Park, Il). We finally utilized an Endoscopy Mask (VBM Medizintechnik, Sultz, Germany; Thomas Medical, Alpharetta, GA). The masks is available in three sizes, infant, child and adult and features a silicone membrane with a 1mm hole in the center, to facilitate the passage of a Endoscopy scope. We threaded the ETT through this hole. In addition the mask has a 60 mm long flexible hose and 15 mm adapter for the attachment of a ventilator circuit. We attached a 15 mm adapter from a spare ETT to this flexible hose and then to bubble tubing and finally to the wall suction at negative 45cm water pressure. We were careful not to allow the mask to seal around his mouth and nose because of the potential for skin pressure necrosis and to facilitate evacuation of the mask. The lack of appreciable Isoflurane odor by caregivers was immediate. **Discussion:** Due the unique nature of this situation we were forced to be resourceful in solving the problem of scavenging Isoflurane with uncuffed ETTs. Literature defines massive airway leaks > 10% (Bernstein, Crit. Care Med. 1995:23(10)1739-1744). The use of the continuous delivery of Isoflurane remains, for our institution a option for the treatment of obstructive and reactive airway disease. In addition pediatric patients will continue to be intubated with uncuffed ETT in both elective and emergent situations.

OF-99-146

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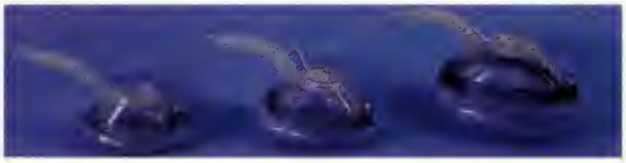

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EVALUATION OF THE PULMONETICS LTV-900 HOME VENTILATOR IN PEDIATRIC VENTILATOR DEPENDENT CHILDREN. **Elizabeth A. McCleary, R.R.T., Kathleen M. Barnum, R.R.T., Mary K Dekeon, R.R.T., Norma J. Maxvold, M.D., University of Michigan Medical Center, Mott Children's Hospital, Ann Arbor, MI**

Background: The response in pressure triggered ventilators is frequently inadequate to meet the needs of a rapidly breathing pediatric patient. Currently, additional equipment is required in conventional home ventilators to provide continuous flow for this population. This additional equipment makes the conventional home ventilator more cumbersome and heavy. The size and portability of conventional home ventilators are frequently cited as barriers to developmental milestones in small patients who are learning to roll, crawl or walk. Additionally, ambulatory pediatric and young adult patients are also impacted by decreased portability. **Methods:** The LTV-900 is an FDA approved home ventilator. The advantages of the LTV-900 over conventional home ventilators include portability and continuous flow capability. The purpose of this study was to evaluate the LTV-900 in a pediatric home ventilator population (8.0-80.0 kg). The evaluation took place at a summer camp for ventilator dependent children run by our medical center. Individual patients were placed on the LTV-900 during all aspects of camp activity (fishing, recreation, meals, etc) to replicate activities of daily living in these children. Caregivers assessed patient comfort and issues of portability during this trial. **Results:** Physical characteristics of the LTV-900 are presented in the table below.

Dimensions	3 in x 10 in x 12 in
Weight	12.6 lbs.
Features	Control, A/C, SIMV, Pressure Support, CPAP, Apnea back-up, Variable rise time, Termination sensitivity, Variable time sensitivity, NPPV
Triggering Mechanism	Flow
Battery Capability	Internal, External
Monitoring Capability	Peak Inspiratory Pressure PEEP Mean airway pressure Total breath rate Exhaled tidal volume I/E ratio Calculated peak flow
Inspiratory time	0.3-9.9 seconds
Retail Cost	$11,333.00

No patient discomfort was noted during any activities or by any patient who participated in this trial. Assessment of portability was deemed superior to conventional home ventilators by all caregivers. User acceptance and ease of use (set-up, adjustment, etc.) was also deemed superior. **Conclusions:** Home ventilator units, which incorporate the additional features of the newer modes of ventilation, can provide a robust spectrum of support for infants through adults. The LTV-900 provides improved characteristics, which improve patient comfort, satisfaction and participation in activities of daily living even in the most diverse of environments.

OF-99-158

EVALUATION OF FLOW DELIVERY ACCURACY IN TWO VENTILATORS DESIGNED FOR NEONATAL THROUGH ADULT APPLICATIONS. Richard D. Branson, BA, RRT,*Dean Hess, PhD, RRT, FAARC,** Shouyan Lee, PhD,*** Adrian De Silva, BSME.*** *University of Cincinnati, Cincinnati OH, **Massachusetts General Hospital and Harvard Medical School, Boston MA, Thermo Respiratory Group, Yorba Linda CA.

Background: Advances in mechanical ventilator design are allowing accurate flow delivery to meet the ventilatory needs of neonatal to adult patients. We designed this study to evaluate the accuracy of a prototype flow controller for such a ventilator design (Thermo Respiratory Group) compared to a commercially available ventilator of such a design (Siemens Servo 300). **Methods:** Each ventilator was set to deliver a tidal volume range of 2 mL to 2000 mL and a flow range of 0.4 L/min to 150 L/min. Compliance and resistance of the lung model were varied (resistance of 500 cm H_2O/L/s and compliance of 1 mL/cm H_2O at 2 mL and 0.4 L/min; resistance of 5 cm H_2O/L/s and compliance of 50 mL/cm H_2O at 2000 mL). The F_IO_2 was held constant at 0.6 and FIO2 was continuously measured. Volumes were measured by accumulating 10 to 2400 breaths (fewer breaths for higher volumes) into a water-sealed Tissot spirometer. Reference volumes were calculated by dividing the total volume collected by the number of breaths. During use of the Servo 300, a correction for the bias flow of 0.5, 1.0, and 2.0 L was made. Volume error was calculated as the difference between set and actual volume divided by set volume. A paired t-test was used to determine statistical significance. **Results:** The table shows data for representative points along the range of volumes tested.

	% error							
	6 mL	20 mL	50 mL	100 mL	480 Ml	1000 mL	2000 mL	Mean ± SD
Thermo	0.85	-0.07	-0.07	-0.07	-1.0	-0.7	0.35	-0.10 ± 0.6*
Servo	4.9	2.41	-1.95	-3.06	-1.82	-0.75	-1.03	-2.23 ± 1.3

*p = 0.005 Thermo vs Siemens

Conclusion: Both ventilators deliver flows accurately across a wide range of tidal volumes. The % error is well within clinically acceptable ranges. Delivered FIO2 was unaffected. The differences in % error were statistically significant. Further research would be required to determine if these differences had clinical implications.

OF-99-154

SHORT TERM USE OF HME DEVICES IN THE PEDIATRIC INTENSIVE CARE UNIT. Katherine Fedor, CPFT,RRT, Perinatal Pediatric Specialist, Steve Davis M.D. Pediatric Intensivist, Cleveland Clinic Foundation, Cleveland, Ohio.

BACKGROUND: The Cleveland Clinic Children's Hospital admits > 900 patients per year to the PICU and performs > 500 open-heart surgeries on children with congenital heart disease. Many of these patients receive short-term ventilation, therefore we believed it would be beneficial to test the efficacy of the use of HME (heat moisture exchanger with bacterial/viral filter) devices in this pediatric patient population. The use of pediatric HME's on short-term ventilator patients, can result in cost savings and may help to reduce the rate of ventilator induced infections. Presently heated wire circuits containing a humidifier canister, a transfer set, a one liter bag of sterile water, and a bacteria filter costs approximately $17.80. A standard non-heated wire circuit costs approximately $6.00 with each HME costing approximately $2.50. If we can safely and effectively use HME devices on these pediatric patients, we can save $6.80 to $9.30 per patient. This could result in annual cost savings of up to $5,000.00 for equipment purchases alone. Additional benefits may be the elimination of condensation within the ventilator circuit resulting in less inadvertent patient lavage, and a reduction in nosocomial pulmonary infections from the bacterial and viral static properties of the HME filter. **METHOD:** All intubated patients weighing > 8 kg were placed on the appropriate HME device (as determined by weight), and an evaluation was performed at the time of extubation to determine the effects on the patient. The evaluation criteria included the type of HME device, the amount of V_D (dead space) required to compensate for the HME volume, the duration of use, the reason for discontinuation, and adverse effects. Microbiology culture results from the expiratory limb of the ventilator circuit are ongoing to test the efficacy of the HME filter. All HME devices were changed every 24 hours and all patients were placed on standard humidification devices following 48 hours of mechanical ventilation. Patients with pulmonary hemorrhage, pulmonary edema, and pneumonia with thick tenacious secretions were excluded from the evaluation. The evaluation process took place over a three week period and consisted of 22 patients. **RESULTS:** None of the 22 patients required early discontinuation of the HME device, 14%(3) of the patients required V_D compensation (volumes equaling the V_D volume of the HME device), none were noted to have documented adverse effects (increased secretions, mucus plugging, or increased WOB), and all were successfully extubated within the first 24 hours of mechanical ventilation. Patients evaluated ranged from 8.1 kg - 90 kg with an average weight of 39 kg, and the average preset V_t for all patients was 10.1 ml/kg. The majority of patients (77%) were intubated > 4 hours but < 24 hours, and the remainder were intubated for < 4 hours. We also observed that the ventilator circuit was completely dry on the inspiratory and expiratory limb with minimal condensation noted at the ETT thus eliminating inadvertent patient lavage. **CONCLUSIONS:** 1. It appears that HME devices can be safely used in select pediatric patients requiring short term mechanical ventilation in the absence of chronic lung disease. 2. Significant cost savings can be realized. 3. We are currently testing for the presence of organisms in the expiratory limb of the ventilator circuit to evaluate the effectiveness of the HME filter.

OF-99-160

EVALUATION OF THE VIA-LVM IN NEONATES WITH CONGENITAL HEART DISEASE

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Background: Arterial blood gases and electrolytes are the most frequently ordered laboratory tests in the critical care environment. They are extremely important in the management of neonates with congenital heart disease, especially in the perioperative period when ventilator management plays a central role in the manipulation of pulmonary vascular resistance. The VIA-LVM (VIA Medical, San Diego, CA) is an in-line, on-demand blood gas/electrolyte monitor. We evaluated the use of the VIA-LVM in neonates following surgery for congenital heart defects. **Method:** Upon return from the operating room, the VIA-LVM was attached to the arterial line. During sampling, blood was drawn for correlation with laboratory analysis using the Corning 855 blood gas and electrolyte analyzer (Chiron Diagnostics, Norwood, MA). Results were compared for bias and precision using Bland and Altman analysis. A total of 140 samples were collected from 7 patients. **Results:** (see Figure 1) pH: r^2= 0.94, bias=-0.02, precision=0.03; pCO_2: r^2=0.86, bias=2.1 mm Hg, precision=3.6 mm Hg; pO_2: r^2=0.95, bias=7.2 mm Hg, precision=11.7 mm Hg,; Sodium: r^2=0.85, bias=2.9 mmol/L, precision=2.5 mmol/L; Potassium: r^2=0.88, bias=0.4 mmol/l, precision=0.5 mmol/L; and Hematocrit: r^2=0.80, bias=–3.8, precision=3.9.

Figure 1

	pH	pCO_2	pO_2	NA	K	HCT
Bias	-0.02	2.1	7.2	2.9	0.4	-3.8
Precision	0.03	3.6	11.7	2.5	0.5	3.9
R^2	0.94	0.86	0.95	0.85	0.88	0.80
Range	7.15-7.6	20.3-54.8	27.1-225.7	128-152	2.3-7.3	31-61
Slope	0.80	0.83	0.95	0.85	0.91	0.8
Intercept	1.5	8.3	-2.12	2.82	0.7	5.77
# Samples	140	140	140	128	132	128

Conclusions: Based on the results of this study, we found the VIA-LVM correlated well with conventional laboratory analysis methods. The VIA-LVM provided rapid results within 70 seconds with minimal blood loss. OF-99-199

THE EFFECT OF SPACER PLACEMENT ON ALBUTEROL DELIVERY IN A PEDIATRIC MECHANICAL VENTILATOR-LUNG MODEL. Ralph A. Lugo, PharmD, Jim Keenan, BS, RRT, Keith Elkins, BS. University of Utah College of Pharmacy and Primary Children's Medical Center, Salt Lake City, Utah.

Background: Aerosolized albuterol is commonly administered by MDI and spacer to mechanically ventilated children in the PICU. Manufacturers recommend placing the spacer in-line in the inspiratory limb of the circuit. We hypothesized that drug delivery may be increased by placing the spacer between the endotracheal tube and the circuit wye. The objective of this study was to compare albuterol delivery between these two positions using two commonly used spacers, ACE® (DHD Healthcare) and Aerochamber® MV (Monaghan Medical Corp.). **Methods:** The model consisted of a Bird VIP ventilator in a volume mode to simulate a 15-kg child with moderate lung disease: V_T 150 mL (10 mL/kg), PIP 45 cm H_2O, rate 12, Ti 0.75 sec, PEEP 4 cm H_2O, FiO_2 0.4, ventilator flow 11 L/min, and gas conditioned to 34° C. The circuit was attached to a 5-mm endotracheal tube (ETT) and a pediatric test lung (Vent Aid® TTL®): compliance = 7.1 mL/cm H_2O and resistance = 95 cm H_2O/L/s. Spacers were rinsed and dried prior to the study. Spacers were placed either in the inspiratory limb immediately proximal to the wye according to the package insert or between the circuit wye and ETT. A Sims filter (Sims Portex) was placed between the ETT and test lung to collect aerosolized albuterol. Ten replicate experiments were performed for each condition. Filters were rinsed with 50 mL of 50% methanol solution and albuterol concentration was analyzed chromatographically by HPLC (99.1% accuracy and CV < 3.3%, n=9). **Results:** Mean (SD) albuterol delivery is presented below.

Spacer Brand	Position of Spacer	Albuterol Delivery (%)
ACE®	Between wye and ETT	27.1 (4.9)*
Aerochamber® MV	Between wye and ETT	26.8 (4.8)**
ACE®	Inspiratory limb	17.0 (1.9)
Aerochamber® MV	Inspiratory limb	18.8 (2.8)

* $p<0.001$ compared to ACE® in inspiratory limb; ** $p<0.001$ compared to Aerochamber® MV in inspiratory limb (ANOVA with Tukey *post hoc* all pairwise comparison)

CONCLUSION: Placement of the ACE® and Aerochamber® MV spacers between the wye and ETT results in superior drug delivery as compared to placement in the inspiratory limb of the circuit. Placement between the wye and ETT is clinically more convenient than in the inspiratory limb as adapting a spacer with pediatric ventilator tubing can be difficult and sometimes impossible.

OF-99-206

THE EFFECT OF ACE® SPACER ON CO_2 ACCUMULATION IN A NEONATAL VENTILATOR-LUNG MODEL. Jim Keenan, BS, RRT, Ralph A. Lugo, PharmD, John W. Salyer RRT, BS, MBA, FAARC. University of Utah College of Pharmacy and School of Medicine, Primary Children's Medical Center, Salt Lake City, Utah.

Background: Aerosolized albuterol (ALB) is commonly administered to mechanically ventilated neonates via MDI and spacer. Most manufacturers recommend placing spacers in the inspiratory limb, immediately proximal to the circuit wye. This location may be impractical during neonatal ventilation due to continuous flow and difficulty in adapting spacers to the circuit. Thus, practitioners often place spacers between the wye and endotracheal tube (ETT). However, large-volume spacers introduced at this location may result in CO_2 retention due to mechanical dead space. The objective of this bench study was to determine the relationship between CO_2 accumulation in an ACE® spacer and the time that a spacer remains in-line between the wye and the ETT. In addition, we sought to determine the effect of different tidal volumes on CO_2 accumulation. **METHODS:** The model consisted of a Bird VIP ventilator in a time cycled (rate 20), pressure-limited, continuous flow (7L/min) mode. The circuit wye was attached to an ACE® spacer and a neonatal test lung. The model was constructed so that inspiratory tidal volume was vented through the test lung into the environment while maintaining a ventilating pressure of 20/1 mm Hg. Expiratory tidal volume was manually returned to the model through a one-way valve by a resuscitation bag attached to a source of 5% CO_2, thus simulating *in vivo* end-tidal CO_2 (35 mm Hg). Inspiratory and expiratory tidal volumes were measured continuously by computerized pneumotachography (Ventrak, Novametrix). For each ventilator breath, expiratory tidal volume (5% CO_2) was manually matched to the inspiratory tidal volume. The accumulation of CO_2 in the spacer was measured by placing a calibrated end-tidal CO_2 monitor (Novametrix) on the ventilator-end of the spacer. Instantaneous CO_2 measurements were obtained from gas displaced from the spacer during exhalation. Three replicate experiments were conducted for each of the three tidal volumes tested: 9 mL, 15 mL, and 25 mL. For each experiment, end-tidal CO_2 was measured for a total of 3 minutes.

RESULTS: Data are represented as mean (SD) end-tidal CO_2 (mm Hg) for each 30 second interval (n=30).

	9 mL V_T	15 mL V_T	25 mL V_T
0-30 sec	0	0.18 (0.70)	0.95 (1.54)
31-60 sec	1.78 (1.19)	2.98 (1.12)	6.38 (1.36)
61-90 sec	3.90 (0.92)	4.75 (0.72)	7.48 (1.31)
91-120 sec	4.98 (0.80)	5.68 (0.87)	6.75 (1.92)
121-150 sec	6.30 (0.79)	5.98 (0.80)	7.32 (1.90)
151-180 sec	6.79 (0.94)	6.48 (0.71)	8.68 (1.56)

CONCLUSION: Accumulation of CO_2 within the spacer increased with time and reached a maximum of 6-7 mm Hg in this model. Due to the short duration of spacer use when administering drugs via MDI, this level of CO_2 exposure is likely clinically insignificant for the majority of ventilated newborns. OF-99-205

PERFORMANCE COMPARISON OF 4 SPACERS IN A PEDIATRIC MECHANICAL VENTILATOR-LUNG MODEL. Ralph A. Lugo, PharmD, Jim Keenan, BS, RRT, Keith Elkins, BS. University of Utah College of Pharmacy and Primary Children's Medical Center, Salt Lake City, Utah.

Background: Aerosolized albuterol is commonly administered to mechanically ventilated children in the PICU. Many institutions have favored switching from nebulized albuterol to MDIs since the latter is more cost-effective. To administer albuterol to intubated children via MDI, several spacers are commercially available. This study compared the efficiency of albuterol delivery among four spacers. A secondary objective was to quantify albuterol rainout within the spacer. **Methods:** The model consisted of a Bird VIP ventilator in a volume mode to simulate a 15-kg child with moderate lung disease: V_T 150 mL (10 mL/kg), PIP 45 cm H_2O, rate 12, Ti 0.75 sec, PEEP 4 cm H_2O, FiO_2 0.4, ventilator flow 11 L/min, and gas conditioned to 34° C. The circuit was attached to a 5-mm endotracheal tube (ETT) and a pediatric test lung (Vent Aid® TTL®): compliance = 7.1 mL/cm H_2O and resistance = 95 cm H_2O/L/s. Spacers were new and unwashed and were placed in the inspiratory limb immediately proximal to the wye according to the package insert. A Sims filter (SIMS Portex) was placed between the ETT and test lung to collect aerosolized albuterol. A minimum of 5 replicate experiments were performed for each spacer. Filters were rinsed with 50 mL of 50% methanol solution and albuterol concentration was analyzed chromatographically by HPLC (99.1% accuracy and CV < 3.3%, n=9). **Results:** Mean (SD) albuterol delivery is presented below.

Spacer Brand	Albuterol Delivery (%)	Rainout in Spacer (%)
ACE® (DHD Healthcare)	19.9 (6.4)*	57.9 (6.1)
Aerochamber® MV (Monaghan Medical Corp.)	26.8 (2.6)†	37.0 (9.1)
Aerovent® (Monaghan Medical Corp.)	6.8 (0.9)	71.3 (10.0)
Minispacer® (Thayer / Allegiance Medical Corp.)	8.5 (0.2)	35.1 (9.5)

* $p<0.05$ compared to Aerovent®; †$p<0.05$ compared to Aerovent® and Minispacer® (ANOVA on Ranks with Dunn's all pairwise comparison)

CONCLUSION: There are clinically important differences in albuterol delivery between four commonly used spacers. The Aerochamber® MV and ACE® spacer performed similarly when tested with this model.

OF-99-207

ALBUTEROL DELIVERY FROM MDI AND SPACER IS REDUCED FOLLOWING SHORT DURATION MANUAL VENTILATION IN A NEONATAL VENTILATOR-LUNG MODEL. Ralph A. Lugo PharmD, Julie Ballard BS, RRT, Keith Elkins BS, University of Utah College of Pharmacy and School of Medicine, Primary Children's Medical Center, Salt Lake City, Utah. **BACKGROUND:** Aerosolized albuterol (ALB) is commonly administered to mechanically ventilated neonates with chronic lung disease. Treatment with a metered dose inhaler (MDI) and spacer is more efficient and less costly than nebulization; however, prolonged use of large-volume spacers in neonates may result in CO_2 retention due to mechanical dead space. To minimize this risk, some institutions limit the time that spacers remain in-line to < 30 seconds. However, this strategy may also limit ALB delivery. The objective of this bench study was to determine the relationship between the time that a spacer is left in place following each MDI actuation and the efficiency of ALB delivery in a neonatal ventilator-lung model. **METHODS:** The model consisted of a Bird VIP ventilator in a time cycled, pressure-limited, continuous flow mode with settings to simulate a 1-kg infant with moderate lung disease. The circuit was attached to a 3.0-mm endotracheal tube (ETT) and a neonatal test lung. Ventilator settings: Vt = 6.5-6.7 mL, flow 9 L/min, pressure 25/4 cm H_2O, rate 30, FiO2 0.4, and gas conditioned to 34°C. There were five methods of administration tested (see table) following two actuations of ALB MDI (Ventolin®). The first three methods utilized an ACE® spacer attached to the ETT followed by 5, 15, and 30 manual breaths after each actuation (anesthesia bag-flow 6 L/min, rate 30, PIP 25 cm H2O). The final two methods utilized an in-line ACE® spacer (placed between the circuit wye and ETT) with the spacer kept in-line for 30 sec and 60 sec after each actuation. A breathing filter was placed between the ETT and test lung to trap aerosolized albuterol. Filters were rinsed with 50 ml of 50% methanol solution and ALB concentration was analyzed chromatographically by HPLC (99.1% accuracy and CV <3.3%, n=9). **RESULTS:** Mean (SD) ALB delivery (%) is presented below. Thirty manual breaths after each actuation increased ALB delivery by 44% and 118% as compared to 15 and 5 manual breaths, respectively. Inserting the spacer in-line and waiting 60 seconds after each actuation improved ALB delivery by 59% as compared to 5 manual breaths after each actuation.

Method of Administration	% ALB Delivery (n=10)
5 manual breaths (10 sec) after each actuation	2.34 (0.5)
15 manual breaths (30 sec) after each actuation	3.55 (1.77)
30 manual breaths (60 sec) after each actuation	5.11 (1.27)*
In-line spacer placement – 30 sec after each actuation	3.69 (1.32)
In-line spacer placement – 60 sec after each actuation	3.73 (0.64)†

*p<0.05 as compared to 5 and 15 manual breaths; † p<0.05 as compared to 5 manual breaths. (ANOVA with Tukey all-pairwise comparison).

CONCLUSION: Manually ventilating for 30 breaths after each actuation resulted in a superior ALB delivery as compared to 15 breaths and 5 breaths. Similar results can be achieved by leaving the spacer in-line for 30-60 seconds after each actuation.

OF-99-208

VENTILATON VARABILITY USING SELF-INFLATING & NON SELF-INFLATING RESUSCIATATION BAGS IN A NEONATAL LUNG MODEL. Jim Keenan BS, RRT, John W. Salyer RRT, BS, MBA, FAARC, Todd Ashby CRTT, Joe Withers CRTT, Natalie Bee CRTT. Primary Children's Medical Center, Salt Lake City, UT, Weber State University, Ogden, UT. **Introduction:** Debate continues among clinicians regarding the merits of self-inflating (SI) and non self-inflating (NSI) bags. We sought to compare the variability of ventilation between the two bags in a neonatal lung model. **Methods:** We compared a SI type (Baxter) and NSI type bag (Drager, Rusch). We tested 5 RCPs and 20 nurses on each bag type. We used a Siemens test lung with a pressure manometer. Subjects were asked to achieve PIP=30, PEEP=4, f=30. PEEP was controlled on the SI bag by using a PEEP valve, and on the NSI by controlling flow into and out of the bag. Data were gathered for 8-10 minutes. PIP and PEEP were measured and stored via computerized pneumotachography (Ventrak, Novametrix Inc.). **Results:** 8717 breaths were analyzed. The distribution of PIP and PEEP sorted by bag type are described in figure 1. We found statistically significant differences in PIP, PEEP and frequency between the two bag types (Mann-Whitney U test all P values < 0.01). Mean ± SD and Coefficients of Variation (SD/Mean) are represented in table 1.

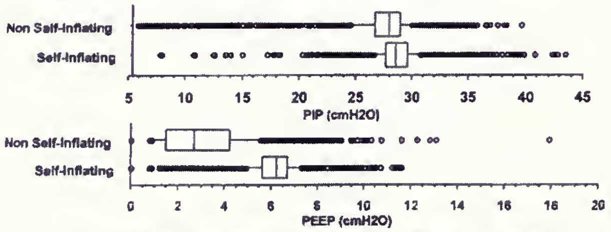

Figure 1: Distribution of PIP & PEEP according to bag type and bagging conditions

	PIP (SD) (CV)	PEEP (SD) (CV)
Self-inflating bag	28.7 (±2.3) (0.079)	6.1 (±1.2) (0.204)
Non self-inflating bag	26.0 (±2.3) (0.152)	3.0 (±1.9) (0.641)

Table 1: PIP and PEEP Mean ± SD and Coefficients of Variation (CV)

Discussion: We found statistical significance between bag types but felt that these differences were not clinically important for PIP. Differences in PEEP were more concerning. It is interesting to note that the NSI bag yielded significantly more breaths under all conditions that were far below the 10th percentile for PIP, suggesting a greater variability of ventilation with the NSI type bags. This is also demonstrated by the much higher coefficients of variation for both PIP and PEEP for the NSI bag. This suggests that maintaining stable ventilatory parameters is more difficult with a NSI bag.

OF-99-212

MANUAL VENTILATION TECHNIQUE VARABILITY IN A PEDIATRIC LUNG MODEL Jim Keenan RRT, BS, John W. Salyer RRT, BS, MBA, FAARC, Todd Ashby CRTT, Joe Withers CRTT, Natalie Bee, CRTT. Primary Children's Medical Center, Salt Lake City, UT, Weber State University, Ogden, UT. **Introduction**: Debate continues among clinicians and disciplinee regarding the merits of self-inflating (SI) and non self-inflating (NSI) resuscitation bags. We sought to test ventilation variability between two clinical disciplines (Respiratory end Nursing) using SI and NSI resuscitation bags in a pediatric lung model. **Methods:** We compared the bagging techniques of 20 nurses and 9 RCPs from our Pediatric Intensive Care Unit using a pediatric lung model. The bag types were SI (Baxter) and NSI (Drager, Rusch). We used a Michigan test lung and instructed subjects to achieve Vt=250 ml, PEEP=4, f=30. PEEP was controlled on the SI bag by using a PEEP valve, and on the NSI by flow into an out of the bag. Each subject used both bags, and data were gathered for 8-10 minutes for each. Vt and PEEP were measured and stored via computerized pneumotachography (Ventrak, Novametrix Inc.). **Results**: 7124 breaths were analyzed. We found statistically significant differences in Vt and PEEP between the two bag types and between disciplines with each bag type (Mann-Whitney U test, all P values < 0.01). The distribution of Vt and PEEP sorted by discipline and bag type is presented in figure 1. Mean ± SD and Coefficients of Variation (SD/Mean) are represented in table 1.

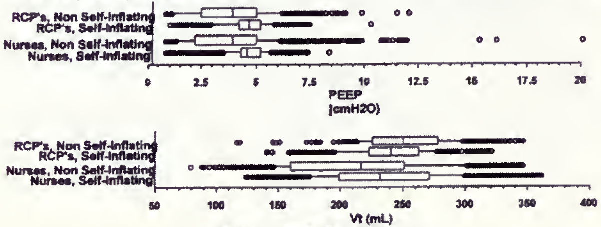

Figure 1: Distribution of PEEP & Vt

	Vt (SD) (VC)	PEEP (SD) (VC)
RCP NSI	253.2 (±33.7) (0.13)	3.8 (±2.0) (0.53)
RCP SI	238.7 (±31.4) (0.132)	4.6 (±1.9) (0.24)
Nursing NSI	215.3 (±55.5) (0.26)	3.8 (±2.0) (0.53)
Nursing SI	234.1 (±50.1) (0.21)	4.6 (±0.9) (0.20)

Table 1: Vt and PEEP Mean ± SD and Coefficients of Variation (CV).

Discussion: There is noted variability in Vt and Peep using the NSI and less using the SI bags between both disciplines. There is less variability using the SI bag between both disciplines. There is also noted variability between disciplines for both bag types. While our findings were statistically significant, clinical importance is difficult to analyze. These data may suggest that RCPs provide manual ventilation that is less variable than nurses and the use of SI bags may be more effective than NSI.

OF-99-211

POLYMER VS METAL HOLDING CHAMBERS FOR YOUNG CHILDREN

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Background: A valved holding chamber (VHC) with mask allows a young child to use metered dose inhalers (MDI). Small children using tidal breathing often don't begin inhaling at the time of MDI actuation. A non-static metal VHC theoretically increases the dose of drug to the patient by decreasing impaction and increasing dwell time in the device for poorly coordinated breaths. However, the advantages of seeing through the VHC are lost. We compared the in vitro performance of a 230 ml. metal VHC to a prototype 155 ml. *transparent* polymer VHC for the delivery of budesonide by MDI. A 2-second delay between MDI actuation and aerosol sampling was used to mimic uncoordinated breaths. **Methods:** Particle size measurements were made with a Marple-Miller cascade impactor at 4.9 l/min, similar to inspiratory flow rates seen in small children. Each VHC was washed in detergent and dried. A budesonide MDI (200 µg/dose) was shaken, primed, and inserted into the VHC adapter. The MDI was actuated, and 2 seconds later the VHC mask was connected to the USP induction port of the cascade impactor. Five doses were delivered to the impactor in this fashion for each VHC, and 5 VHC's of each type were studied. The stages of the impactor and the VHC were then assayed for budesonide by HPLC.

	Mass (µg) <3.1 µm	Mass (µg) <4.7 µm	Mass (µg) >4.7 µm	Total Dose (µg)	Retained Dose (µg)
Polymer VHC	11.3 +/- 1.5	32.6 +/- 2.9	12.9	45.5 +/- 5.3	118.2 +/- 18.5
Metal VHC	9.4 +/- 1.2	32.5 +/- 1.4	30.9	63.4 +/- 5.0	110.3 +/- 6.4

Discussion: The dose retained in the VHCs were similar (55-60% of MDI dose). Although the metal VHC allowed more total drug to escape the device, the fine particle mass (FPM=mass of drug < 4.7 µm aerodynamic diameter), which is related to the amount of drug likely to deposit in the lower airways, was equivalent between polymer and metal devices (p=0.95). The polymer VHC filtered the coarse particles (> 4.7 µm) better than the metal VHC. Coarse particles are more likely to impact in the upper airway, and have the potential to cause side effects.
Conclusion: Under conditions likely to occur with young children, the prototype transparent polymer VHC delivered equal FPM and was superior to the metal VHC at eliminating coarse particles from a budesonide MDI. Aerosol devices should always be tested under conditions that simulate clinical use. OF-99-238

Letters From Home.

Dawn and Cameron
Spring 1999

Cameron
Spring 1999

To Tony van den Berg:

I wanted to personally send my thanks to your company as your TBird® Legacy ventilator proved to be the perfect solution to meet our homecare needs. Your TBird® Legacy ventilator has enabled my son to make great strides in his abilities to normally function like other children. The features of the ventilator have given him much more control and even greater mobility and freedom. Although he still isn't walking, Cameron is able to get on his hands and knees and scoot pretty well.

We've also noticed that since using the TBird® Legacy, he is much less fatigued. Cameron has shortened his naps by an hour and is staying up later every night. He can even be taken off the ventilator long enough to play for a short time in the bathtub. Cameron's breathing sounds so much better than just a few months ago that I'm very encouraged that he will successfully be weaned from the ventilator.

My sincerest thanks,
Dawn Kisner

The TBird® Legacy from Bird

Family members of ventilated patients will tell you: with the right ventilator, providing comfortable support in a home care environment can be uncomplicated and dramatically improve the quality of life for their loved ones. Unfortunately, the limitations of most ventilators have made caring for home care patients a real challenge.

Until Now.

The TBird® Legacy is one of today's most dependable high performance ventilators for the home care market. Lightweight and compact in its design, the TBird® Legacy delivers the benefits and synchrony of flow triggering and Pressure Support. Pressure Support greatly reduces the patient's work of breathing as well as weaning time.[1] The result is a patient that is less fatigued and better able to manage the everyday tasks of life.

The first home care ventilator to use a turbine, the TBird® Legacy easily supports the breathing demands of patients while freeing the user's home from bulky compressors. The TBird® Legacy uses a simple patient interface with color-coded controls. The combination of an internal battery and an optional external power inverter system provides patient's with unprecedented freedom and complete mobility. To learn more about the effectiveness of the TBird® Legacy homecare ventilator contact Thermo Respiratory Alternate Care at (877) TRG-TRAC (874-8722). Or visit our Web site at http://www.thermoresp.com

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[1] Branson, R.D., RRT & Davis, K., MD (1995). Work of breathing imposed by five ventilators used for long-term support: the effects of PEEP and simulated patient demand. Respiratory Care (Vol. 40, 12).

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INVASIVE APPLICATION OF PROPORTIONAL ASSIST VENTILATION (PAV) USING SINGLE-LIMB CIRCUIT - NO EVIDENCE OF C02 RETENTION

R Graham RRT[#], L Thompson RN PhD(c)[*], J Barr MD[+#], E Bertaccini MD[+#],
V Carrieri-Kohlman DNSc[*], E Geller MS, MD[+#]
VA Palo Alto HCS[#], Stanford U School of Medicine[+], UCSF School of Nursing[*]

Background: Pressure Support Ventilation (PSV) and Proportional Assist Ventilation (PAV) are two modes of partial ventilatory support that assist spontaneously breathing patients. The primary difference between PSV and PAV is in the application of airway pressure once a spontaneous breath has been initiated. With PSV, patient effort and ventilator pressures are independent of each other; in PAV airway pressure is proportional to patient effort. Rebreathing (and retention) of $C0_2$ in BiPAP® Ventilators with single limb circuit and fixed-resistance exhalation device has been addressed (Ferguson, AJRCCM 151:1126-1135, 1995), yet no studies to date exist investigating $C0_2$ retention in the invasive use of PAV in a single limb circuit. This study measured ABG values using PAV delivered by the Vision® ventilator (single limb circuit with Plateau® exhalation valve, Respironics, Inc, Murrysville, PA) and PSV delivered by the 7200ae® ventilator (dual limb circuit with internal exhalation valve, Nellcor Puritan Bennett, Carlsbad, CA). **Method:** 10 post-operative, intubated patients were studied during weaning from mechanical ventilation. PSV and PAV were randomly applied to all patients at each level, starting at maximal assist and decreasing to 40% assist or onset of dyspnea. PSV_{max} (100% Assist) was defined as the pressure that produced a V_t of 10ml/kg (mean = 19cmH20±4); PAV_{max} (80% assist) was defined as 80% of the patient's Resistance (mean = 14.5 ±5) and Elastance (mean = 29.0 ±10) obtained by static measurement while receiving volume ventilation at a V_t of 10ml/kg. Measurements of the following parameters were obtained at the end of each 15 minute study period: V_t (liter), RR (bpm), V_e (liter), pH, $PaC0_2$ (mmHg), $Pa0_2$ (mmHg), & $Sp0_2$ (%). **Results:** mean (SD); Repeated ANOVA, p<.05=*

Mode	Assist	V_t	RR	V_e	pH	$PaC0_2$	$Pa0_2$	$Sp0_2$
PAV	80%	.493(.18)	20(4)	9.4(3.2)	7.39(.06)	40.9(5.9)	97(30)	97(3)
PAV	40%	.436(.14)	22(5)	8.8(1.3)	7.40(.05)	40.2(5.5)	97(29)	97(3)
PSV	100%	.716(.14)*	16(5)*	10.8(2.5)	7.40(.04)	38.5(5.5)	91(18)	97(3)
PSV	40%	.550(.16)	21(4)	10.4(1.9)	7.38(.06)	41.2(6.7)	96(25)	97(3)

Conclusions: There was no significant difference in $PaC0_2$, pH, V_e, or indices of Oxygenation. There was statistical significance between V_t and RR with PAV compared to PSV. These data suggest that PAV may allow stable, post-operative patients more control over their own breathing pattern without evidence of $C0_2$ retention with the use of a single limb circuit.

Study made possible by grant from Respironics, Inc.
L Thompson was the recipient of a Fellowship Grant from Respironics, Inc.

OF-99-017

EXHIBITORS,

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EMERGENCY DEPARTMENT USE OF NON-INVASIVE POSITIVE PRESSURE VENTILATION: PREDICTORS OF SUCCESS OR FAILURE FROM A RETROSPECTIVE CHART REVIEW.

Tim Carroll RRT, Lisa Nesbitt RRT, David Swift RRT. Ottawa Hospital, Civic Campus, Ottawa, Ontario.

Background: Non-invasive positive pressure ventilation (NIPPV) has become a viable option to avoid intubation in patients with acute respiratory failure. NIPPV is indicated for a variety of medical conditions including COPD, asthma, pulmonary edema and pneumonia. However, the results of prospective, randomized, controlled studies do not yet provide a uniform answer to guide its clinical use for acute respiratory failure. Documentation of predictors of success of NIPPV is needed to assist clinicians in the Emergency Room to select the most appropriate treatment option when respiratory failure appears imminent. The aim of this research project is to identify factors associated with success (survival without intubation) or failure (intubation or death) of NIPPV. **Methods:** A retrospective chart review was undertaken of 73 male and 81 female patients (mean age 73.26 years) who received NIPPV in the Emergency Room of an acute care teaching hospital. Information was collected on: admitting diagnosis, vital signs at commencement of NIPPV, blood gases at commencement of NIPPV, medications given, final status, and side effects of NIPPV. **Results:** Step-wise logistic regression analysis was used to identify the factors that predicted successful patient outcome when NIPPV was used. These factors were the oxygen saturation level at the time of commencing NIPPV (OR = 1.19, CI (1.07, 1.32), p = .0019) and the bicarbonate level at the time of commencing NIPPV (OR = 0.91, CI (0.85, 0.99), p = .0211). Of the patients studied, 60.3% survived without intubation and 39.7% were intubated or died. **Discussion:** Review of the data suggests that immediate assessment of saturation and bicarbonate may identify patients for early intubtion thus decreasing morbidity and mortality. Further research is required to determine a standardized aggressive approach to those patients who predictors suggest are not candidates for NIPPV.

OF-99-028

INSPIRED CARBON DIOXIDE DELIVERY ON THE SERVO 300 WITH SPONTANEOUSLY BREATHING PATIENTS

Suzanne M. Durning, BS, RRT, P/P Spec., Theresa R. Schultz, BA, RRT, CPFT, P/P Spec., Linda A. Napoli, BS, RRT, RPFT, P/P Spec., The Children's Hospital of Philadelphia, Philadelpha, PA

Inspired carbon dioxide has often been administered to increase pulmonary vascular resistance and limit pulmonary blood flow in patients with single ventricle physiology where the potential for excessive pulmonary blood flow exists.[1] At our institution current practice is to deliver inspired carbon dioxide to patients requiring mechanical ventilation via the Servo 900C. Steady state can be easily achieved by blending CO_2 with air/O_2 mixture prebellows into the low-flow inlet. Actual inspired CO_2 is then continously measured at the ventilator outlet (pre-humidifier, inspiratory limb). Spontaneous breathing does not alter percent of CO_2 delivery. With the addition of the Siemens Servo 300, which does not have a bellows, to our ventilator fleet, we evaluated the effectiveness and accuracy of blending inspired CO_2 at the outlet of the ventilator on the inspiratory limb. With spontaneous breathing on the Servo 300, the patient's respiratory rate varies breath to breath, causing fluctuations in the level of inspired CO_2. These fluctuations may lead to hemodynamic instability of the patient. **Methods:** Bench studies on the Servo 300 were done with and without simulated spontaneous breathing. CO_2 of 10 mm Hg was added at the outport of the ventilator. Actual inspired CO_2 was monitored continuously (pre-humidifier) on the inspiratory limb with an adequate circuit volume for mixing to occur. The Nellcor 6000 CO_2 monitor was used to measure inspired CO_2. The FIO_2 was set at .21 on the air/O_2 blender.

Results:

Mode	Vt	Set RR	Total RR	Pressure Support	Measured CO2
PRVC	100 cc	20	20	N/A	10 mm Hg
PRVC	100 cc	20	24	N/A	7-9mm Hg
PRVC	100 cc	20	48	N/A	4-6mm Hg
PRVC	200 cc	20	20	N/A	10 mm Hg
PRVC	200 cc	20	24	N/A	4-6mm Hg
SIMV	100 cc	20	20	0	10 mm Hg
SIMV	100 cc	20	24	10 cm	5-8 mm Hg
SIMV	100 cc	20	48	10 cm	2-5 mm Hg
SIMV	200 cc	20	20	0	10 mm Hg
SIMV	200 cc	20	24	0	3-6mm Hg
SIMV	200 cc	20	24	10 cm	2-6mm Hg

Conclusion:
Delivery of inspired carbon dioxide can be safely and effectively delivered through the Servo 300 ventilator for patients without spontaneous breathing. In spontaneously breathing patients, the Servo 900C would be preferred, to prevent the variability of inspired CO_2 levels.

1. Jobes,D.L., et al.

OF-99-041

A CLINICAL EVALUATION OF THE ALLEN-BEAN BI-LEVEL INDEX DESIGNED TO IDENTIFY LONG-TERM NONINVASIVE NOCTURNAL VENTILATORY CANDIDATES

by Desmond Allen, PhD, CRTT and Robert Bean, RRT

BACKGROUND: The Allen-Bean Bi-level Index is a clinical protocol designed to identify potential long-term noninvasive nocturnal Bi-level ventilatory candidates. This study is a clinical trial of the protocol in which prime COPD candidates specifically are identified. By attaching a numerical value to each parameter, the index provides a final probability score. Objective criteria consist of the type and stage of disease, age, weight, $SpaO_2$-at rest and with exertion, $ETCO_2$, RR, HR, histories of hospitalizations, unscheduled physician visits, endotracheal intubations, hypertension and sleep apnea. The subjective criteria consist of the perceived severity of dyspnea, decreased activity, quality of sleep and oxygen use.

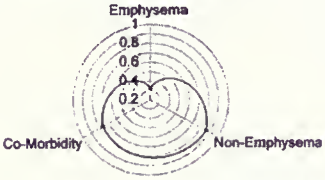
METHOD: Spanning ten-months, the study focused on a core population of 380 home O_2 patients. Excluding a terminal co-morbidity, all new COPD patients, and many selected at random, were screened by two respiratory therapists via clinical assessment and interview.

RESULTS: In all, 221 COPD patients were screened. 88 were identified as prime candidates. 76 requests for free Bi-level trials were sent to attending physicians. 60 requests were approved. 26 patients were unwilling to comply. 32 patients did comply, with 2 eventually dropping out of the study. All 30 patients completing the trial elected to continue treatment. Overall success was achieved in 86% of the non-emphysema, 77% in the co-morbidity, and 32% in the emphysema-alone patients (figure 3).

CONCLUSIONS: The Index successfully identified potential long-term Bi-level candidates. Emphysema-alone patients were the most likely to refuse treatment, however, those who did comply experienced significant benefit. Thus, once identified two very important factors must be considered, the patient's willingness and the attending physician's actual encouragement for the therapy. This cannot be overstated and is aptly demonstrated by the fact that 86% of the compliant, and 89% of the noncompliant, were emphysema-alone patients. Among these prime candidates, compliance seemed more a motivational than a physical issue. Active, enthusiastic physician participation increased compliance, while mere passive approval often hindered patient motivation.

Percentage of Success Type

Figure 3



OF-99-060

THE ALLEN-BEAN BI-LEVEL INDEX

by Desmond Allen, PhD, CRTT and Robert Bean, RRT

BACKGROUND: The Allen-Bean Bi-level Index is a clinical tool designed to identify potential long-term noninvasive nocturnal Bi-level candidates. Such therapy has proven to significantly decrease morbidity, mortality, the need for endotracheal intubation, the number and duration of hospital admissions, and to significantly improve the overall quality of life. However, despite many studies and articles on the subject, until now a detailed protocol to identify potential candidates has yet to appear.

METHOD: Based upon present research data and years of clinical experience, the index provides a probability score that effectively identifies candidates likely to benefit from long-term Bi-level therapy. A score ≥100 indicates a prime candidate.

RESULTS: The index was tested in a clinical study which took place over ten-months and focused on a core population of 380 home O_2 patients. 221 COPD patients were screened. 88 prime candidates were identified.

EXPERIENCE: The index was created by two seasoned respiratory therapists, Desmond Allen, PhD, CRTT and Robert Bean, RRT. Each have broad backgrounds with 25 years experience in the field.

CONCLUSION: With this index to reference, even the inexperienced clinician can successfully identify potential Bi-level candidates likely to benefit from the use of long-term noninvasive nocturnal Bi-level therapy.

ALLEN-BEAN BI-LEVEL INDEX

Medical Diagnosis

___ COPD Stage 1, add 30
___ COPD Stage 2, add 40
___ COPD Stage 3, add 25
___ Restrictive Wall, add 45
___ Neuromuscular, add 45
___ OSA, add 50
___ OSA, CHF & Arrhythmia, add 50
___ Hypertension Hx, add 10
___ Obesity, add 10
___ Gross Obesity, add 20

Clinical Assessment & Hx

___ HR> 80, add 0.5 ea >80
___ RR, add 0.5 ea > 10
___ $ETCO_2$ add 2 ea mm Hg > 40
___ SaO_2 rest on room air, add 2 ea mm Hg < 98
___ SaO_2 on room air with exertion, add 2 ea mm Hg < 98
___ SaO_2 Recovery, add 2 ea 15 sec
___ Age > 70 < add 1 ea.< 70, subtract 1 ea > 70
___ Intubations, add 10 ea in last 2 yrs
___ Hosp/ER/Phys. visits, add 5 ea in last 2 yrs
___ Dyspnea, none-5, slight+5, moderate+10, severe+15
___ > Use of O_2, none-5, slight+5 , mod+10, severe+15
___ < Function, none-5, slight+5 , mod+10, severe+15
___ Quality of sleep, poor+20, fair+10, good+0, excel-10
___ **Total** (A score of ≥100 is a Prime Candidate)

OF-99-061

EXPIRATORY SYNCHRONY DURING PRESSURE SUPPORT VENTILATION: A MATHEMATICAL APPROACH

Hong-Lin Du, MD and Yamada Yoshitsugu, MD.
Clinical Research Department, Newport Medical Instruments Inc., Newport Beach, California; Surgical Center, The Institute of Medical Science, University of Tokyo, Japan.

A mathematical model was developed in order to provide qualitative information for clinicians to select expiratory trigger sensitivity and optimize expiratory patient-ventilator synchrony during pressure support ventilation (PSV). The model used a first order equation for the respiratory system and a second-order polynomial function for the inspiratory muscle pressure. Solving the model yielded an equation of the inspiratory flow during PSV as follows:

$$\frac{\dot{V}(t)}{P_{ps}/R} = \frac{1}{1-(\tau_v/T_I)(T_I/\tau)}\left(e^{-\frac{T_I}{\tau}\cdot\frac{t}{T_I}} - e^{-\frac{T_I}{\tau_v}\cdot\frac{t}{T_I}}\right) + \frac{2}{P_{ps}/P_{mus\ max}}\cdot\left(\frac{\tau}{T_I}\right)\cdot\left[\left(1+\frac{\tau}{T_I}\right)\cdot\left(1-e^{-\frac{T_I}{\tau}\cdot\frac{t}{T_I}}\right)-\frac{t}{T_I}\right]$$

Computing the inspiratory flow rates based on this fundamental equation revealed the following results: 1. The ratio of the flow at the end of the patient neural inspiration to peak inspiratory flow (V_{TI}/V_{peak}) during PSV is determined by the set support pressure level (P_{ps}), maximal patient inspiratory muscle pressure ($P_{mus\ max}$), time constant (τ) of the respiratory system, and patient neural inspiratory time (T_I); 2. V_{TI}/V_{peak} is affected more by τ/T_I than by $P_{ps}/P_{mus\ max}$. At the same neural T_I, V_{TI}/V_{peak} is increased by τ/T_I in an exponential pattern within the full data ranges. Within the specific mechanic ranges of adult conditions, V_{TI}/V_{peak} has an excellent linear correlation with τ at a given T_I. Increase in $P_{ps}/P_{mus\ max}$ slightly shifts the $V_{TI}/V_{peak} - \tau/T_I$ curve to right; 3. Single fixed levels of the flow termination criterion used in mechanical ventilators will always have chances of both synchronized termination and asynchronized (premature and delayed) termination, depending on the patient mechanics. When T_I remains unchanged, the expiratory synchrony is primarily dependent on τ of the respiratory system. Increase in τ causes more opportunity of delayed termination and less chance of premature termination. Increase in the set P_{ps} or decrease in $P_{mus\ max}$ narrows the synchronized zone, leaving the inspiratory termination predisposed to be in asynchrony. Increasing the expiratory trigger sensitivity shifts the synchronized zone to right, causing less delayed and more premature terminations. A faster P_{mus} decay after inspiration or expiratory muscle activity broadens the synchronous zone and narrows the delayed termination zone. In conclusion, our mathematical model provides useful qualitative information for clinicians to adjust expiratory trigger sensitivity in order to optimize expiratory synchrony during PSV.

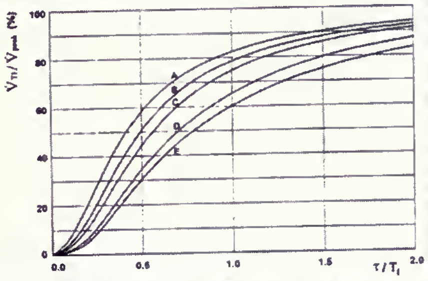


Figure: Termination flow percent as the function of the time constant - neural inspiratory time ratio at different Pps/Pmus levels. Pps/Pmus is 1/3 (A), 2/3 (B), 1(C), 2 (D), and 3 (E)

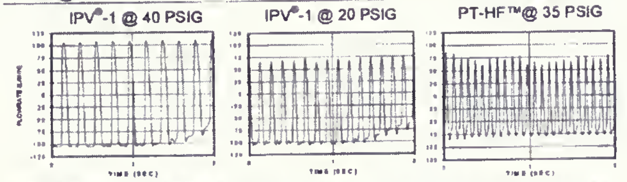
OF-99-070

COMPARISON OF MINUTE VOLUME DELIVERED WITH HIGH FREQUENCY VENTILATION USING TWO AIRWAY CLEARANCE DEVICES

David A. Blackney, RCP, RRT, Pulmonary Services, Sutter Children's Center, Sacramento, CA, USA

BACKGROUND: High frequency ventilation has been used in devices to create intrapulmonary percussive effects and promote airway clearance. Two percussive devices were evaluated, and the flow and volume waveform characteristics were compared for high frequency oscillation. Tha parameters important for intrapulmonary percussive type ventilation are: *f* - oscillation frequency (Hz), proximal *PIP* - Peak Inspiratory Pressure (cm-H_2O), *OTV* - Oscillatory Tidal Volumes (ml), and *MV* - Minute Volume (Liters) during inhalation and exhalation.
METHODS: Each device was connected to a pressure tap and a flow sensor proximal to the mouthpiece to record pressure and flow waveforms using a computer data acquisition system sampling pressure at 100 Hz. Model IPV®-1 (Percussionaire® Corp.) was operated at both 20 and 40 PSIG at "EASY" setting, and PercussiveTech HF™ (VORTRAN Medical Technology 1, Inc.) was operated at 35 PSIG (approximately 60 L/min device flow). A 50 PSIG compressed air source was used. A trained respiratory care practitioner operated the devices and recorded pressure waveforms.
RESULTS: The results of this evaluation are summarized below with flow waveforms.

Device	*f (Hz)*	*PIP (cm-H_2O)*	*OTV_{INHL} (ml)*	*OTV_{EXHL} (ml)*	*MV_{EXHL} (L)*
IPV®-1 @ 40 PSIG	5	27.6 ± 4.2	85.6 ± 3.8	221.3 ± 4.2	66
IPV®-1 @ 20 PSIG	7	23.2 ± 0.5	28.2 ± 0.6	148.7 ± 2.9	82
PT-HF @ 35 PSIG	11	21.6 ± 0.5	22.2 ± 1.7	61.8 ± 2.1	40



DISCUSSION: The results indicate that oscillation frequencies vary slightly depending on the setting of the devices. The oscillation frequency *f* for the IPV®-1 was from 5 to 7 Hz and tha PT-HF was at 11 Hz. The exhalation Minute Volume ($MV_{EXHL} = OTV_{EXHL} \times f$) delivered by the IPV®-1 was 62 to 66 liters per minute at various frequencies.
In comparison, the PT-HF delivered about 40 liters per minute at higher frequencies.
CONCLUSIONS: The flow waveform of the PT-HF is compatible to that of the IPV®-1. PIP is essentially the same with the PT-HF oscillating at higher frequencies and at a lower pressure. The MV_{EXHL} results suggest that patients were ventilated during the exhalation phase through the use of high frequency oscillation. Further studies should be done to evaluate the impact of volume delivered on patients during exhalation and on the effectiveness of airway clearance at various frequencies.

Supported by VORTRAN Medical Technology 1, Inc.

OF-99-077

VENTILATOR SETTINGS AND VOLUME MEASUREMENT DEVICE AFFECT THE RAPID SHALLOW BREATHING INDEX.

Steven Holets RRT, CCRA, Rolf Hubmayr MD, and Curtis F Buck CRNA, RRT, Mayo Medical Center, Rochester MN.

Background: Virtually all weaning algorithms supported by large clinical trials use a threshold in the rapid shallow breathing index (frequency to tidal volume ratio, f/VT) to triage patients. Based on the work of Yang and Tobin this threshold is usually $\approx 100\ \text{min}^{-1}\ \text{L}^{-1}$. We tested the hypothesis that the choices of ventilator settings and volume measurement device affect the f/VT and by inference its predictive value in weaning decisions making.

Methods: f/VT was measured under 3 experimental conditions (C1,2,3) in 21 patients, who fulfilled standard weaning screening criteria. During C1 and C2 patients received pressure support of 3 and CPAP of 5 cm H2O and O2 enriched air from a Nellcor-Puritan Bennett 7200 ventilator. During C3 patients were disconnected and breathed room air. During C1 f/VT was derived from the expired volume output of the ventilator. During C2 and C3 f/VT was derived using a precision calibrated Novametrics Ventcheck mechanics monitor. One minute averages in f, VT and f/VT and the associated biases due to ventilator settings (C2 vsC3) and measurement device (C1 vs. C2) were compared using t statistics.

Results: Under C1, 2&3 the average f/VT rose from 63 to 71 & 106, respectively. These differences across experimental conditions are largely explained by an instrument bias in VT (C1-C2=0.05L) and by a true change in breathing pattern when pressure support and O2 supplementation are withdrawn.

Conclusion: We conclude that the choices of ventilator settings and measurement equipment have profound effects on the f/VT and that the predictive values reported by Yang and Tobin should only be adopted if the measurement is performed during unsupported breathing of room air.

OF-99-092

PRESSURE ASSIST-CONTROL ON A CONVENTIONAL VENTILATOR ADAPTED FOR NON-INVASIVE MASK VENTILATION.

Robert McConnell, RRT, Jhaymie Cappiello, RRT, Jon Umbdenstock, RRT, Neil MacIntyre, MD, Duke University Medical Center, Durham, NC

BACKGROUND/HYPOTHESIS: Non-invasive mask ventilation commonly uses specially designed bi-level pressure targeted ventilators. Adaptation of a conventional ventilator for this purpose offers the advantages of a double limb circuit (ie less CO_2 rebreathing), more precise FiO_2 delivery, and the immediate availability of a conventional ventilator should intubation be required. We hypothesized that a conventional ventilator (TBird AVS System - Thermo Respiratory Group, Palm Springs, CA) set in the pressure assist/control mode (ie pressure targeted - time cycled) could function effectively as a non-invasive positive pressure ventilator (NPPV) in patients with acute exacerbation of COPD. PATIENT POPULATION: Consecutive patients that presented to the Emergency Department with acute exacerbation of COPD were studied. Entry criteria included dyspnea, respiratory rate >25, use of accessory muscles or abdominal paradox, and moderate hypercarbia ($pH < 7.35$ with $PaCO_2 > 45$mmHg). Patients were excluded if they were hypoxemic secondary to pneumonia, if they exhibited signs and symptoms of congestive heart failure, or if they were either uncooperative or incoherent. METHODS: The ventilator was equipped with a conventional double limb circuit with the addition of a full-face mask and supportive headgear attached to the wye (patient connection adapter) of the circuit. Pressure assist/control ventilation was attempted for at least 90 minutes with the range of ventilator settings as follows: FiO_2(0.30 - 0.40), Inspiratory Pressure (10-14 cmH_2O), PEEP (3-5 cmH_2O). In three patients, no backup rate was provided; in the other two, a rate of 14 was set. Pre and post treatment blood gas and vital sign data were analyzed by paired t tests. RESULTS: A total of 5 patients were enrolled and successfully ventilated by NPPV with the conventional ventilator. Following treatment, there were significant reductions in $PaCO_2$, blood pressure (BP) and respiratory rate (Table):

Mean Values (±SD)

	Pre Therapy	Post Therapy	Change
pH	7.27 (±0.06)	7.32 (±.05)	0.05 *
$PaCO_2$	82.4 (±17)	70.8 (±19)	-11.6 *
FiO_2	0.63 (±.3)	0.32 (±.07)	-0.30
P/F Ratio	180 (±47)	249 (±53)	69
HR	117 (±25)	119 (±27)	2
BP	156 (±18)	140 (±19)	-12 *
RR	38 (±10)	23 (±3)	-15 *

*P<0.05

None of the 5 patients required intubation. Only 2 were admitted to the ICU (3 days or less duration) and all were discharged from the hospital within 5-9 days after admission. CONCLUSION: A conventional ventilator in the pressure assist/control mode can be a safe and effective non-invasive mask ventilator, often avoiding the need for an artificial airway and the resultant risks involved.

OF-99-093

CLINICAL COMPARISON OF TWO IPPB DEVICES: PIPER-IPPB™ & BIRD® IPPB

Mario Romano, RCP, Mercy General Hospital, Medical Intensive Care Unit, Sacramento, CA, USA

BACKGROUND: Intermittent Positive Pressure Breathing (IPPB) is a technique used to provide short-term or intermittent mechanical ventilation to augment lung expansion, deliver aerosol medication, or assist ventilation[1] for the treatment of atelectasis. The use of IPPB to provide large inspiratory volumes when patients cannot take deep breaths has been found to be beneficial in the management of atelectasis where other approaches have failed[2]. Since the Bird® IPPB is no longer being manufactured, the shortage of spare parts makes it difficult to maintain existing units. This study compares a new single patient use IPPB device, the Piper-IPPB™ (VORTRAN Medical Technology 1), with the conventional IPPB - Bird® Mark 7® Positive Phase Medical Respirator (Bird Corporation).

METHODS: Two clinically stable female patients, one with COPD and one with CHF (ages 72 and 74), received 10 minutes of the Bird IPPB and the Piper-IPPB in alternate therapy sessions. Each treatment included 0.5 cc albuterol (2.5 mg), unit dose ipartropium bromide (0.5 mg), and 10 cc normal saline. A compressed gas source was used for both devices and pulse oximetry (O_2 Sat.), heart rate (HR), blood pressure (BP), and breath sounds (BS) were monitored before and after each therapy session.

RESULTS: Patients' vital signs are summarized below:

Dx	COPD				CHF			
Devices	Piper-IPPB™		Bird® IPPB		Piper-IPPB™		Bird® IPPB	
PIP Set	20 cm-H_2O		15 cm-H_2O		25 cm-H_2O		25 cm-H_2O	
FiO_2 Set	Room air		Room air		100% O_2		100% O_2	
Tx	Pre	Post	Pre	Post	Pre	Post	Pre	Post
O_2 Sat.	93	93	94	93	93	99	93	98
HR	92	90	100	101	105	103	104	107
BP	136/67	128/64	141/70	142/70	148/45	154/50	139/46	151/49
BS	Crackle at bases				Diminished at bases			

DISCUSSION: One patient reported that the work of breathing was easy and that the inspiratory flowrate was just right for both devices. The other patient reported that the inspiratory flowrate for both IPPBs was too slow and that the work of breathing for Piper-IPPB was slightly harder. No significant changes in vital signs were noted with either device. Both patients found the Piper-IPPB easy to use and preferred it to the conventional Bird-IPPB.

CONCLUSIONS: The Piper-IPPB can be a safe and effective method of delivering IPPB treatment without the need for conventional IPPB capital equipment. Using a larger patient population in a future study can help establish the Piper-IPPB as a safe and effective treatment modality.

Supported by VORTRAN Medical Technology 1, Inc.

[1] Agency for Health Care Policy and Research (AHCPR). Health Technology Report: Intermittent Positive Pressure Breathing (IPPB) Therapy. 1991, Number 1.

[2] Walter J. O'Donohue, Jr., M.D., F.C.C.P.: Maximum Volume IPPB for the Management of Pulmonary Atelectasis, Chest, December 1979, 76:6, 683-687.

OF-99-100

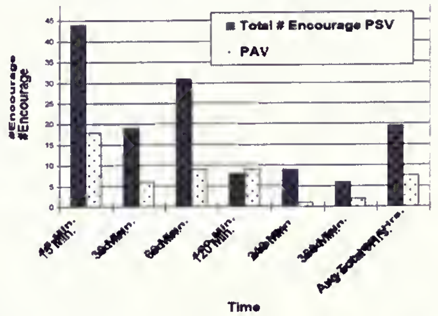
Ventilator Management by Respiratory Therapists (RTs) during a Multicenter Randomized Trial of Non-Invasive Proportional Assist Ventilation (PAV) VS. Pressure Support Ventilation (PSV) in Acute Respiratory Failure (ARF) Pts.

P Gay MD, S Holets RRT, CCRA, D Hess PhD, D Nelson RRT, N Hill MD. Mayo Clinic-Rochester, MN; Mass Gen Hosp-Boston, MA; Rhode Island Hosp-Providence, RI

Background: We have reported that PAV and PSV modes resulted in similar intubation rates and mortality in pts with ARF (*Am J Resp Crit Care* 1999; 159:A14). We wished to test whether excessive effort by RTs was needed and provided to patients for the PAV vs PSV mode.

Methods: Pts with ARF were randomized to receive PAV or PSV mode and we prospectively charted both the number of times pts needed encouragement (#ENC) to continue and how many inspiratory ventilator setting changes (#IPAP) were required for optimizing each mode.

Results: There was a significantly higher %pts encouraged ($p < 0.02$) and



(M SV vs PAV= 19.5 ± 15.2 vs 7.5 ± 6.2). There was no significant difference ($p > 0.15$) in the #IPAP changes between the 2 modes (#IPAP-PSV vs PAV=2.8 ± 1.9 vs 5.5 ± 3.1). The #ENC for the first 6 hours is shown.

Conclusions: PAV mode required similar ventilator setting changes and less pt encouragement effort than PSV mode in this clinical trial.

Study funded by Respironics Inc. Murraysville, PA.

OF-99-104

THE EFFECT OF FREQUENCY ADJUSTMENT DURING HIGH FREQUENCY OSCILLATORY VENTILATION ON HEMODYNAMICS AND GAS EXCHANGE IN AN ANIMAL MODEL.

Michael Gentile, RRT, Damian Craig, MS, George Quick, Christopher Hubble, MD, Ira Cheifetz, MD. Duke University Medical Center, Durham, NC.

Background: High frequency oscillatory ventilation (HFOV) is a technology increasingly utilized to support intensive care patients with acute lung injury. Controversy exists concerning the ideal frequency settings to use. The HFOV frequency setting not only affects the ventilator rate but also alters the delivered tidal volume (frequency is inversely proportional to tidal volume). The purpose of this study was to evaluate the effect of different HFOV frequencies on gas exchange and cardiopulmonary hemodynamics. We hypothesized that a lower frequency (i.e. increased tidal volume) would improve gas exchange but at the expense of cardiopulmonary function.

Method: Five infant swine with a mean weight of 6.06 ± 1.4 kg were placed on HFOV. Each animal was instrumented with an arterial line, pulmonary artery flow probe, right ventricular pressure catheter, and pulmonary artery catheter. HFOV settings included amplitude 40 cmH_20, mean airway pressure 10 cmH_20, FiO_2 0.40, inspiratory time 33%, and bias flow 20 lpm. Animals were ventilated at 5 Hz or 12 Hz for periods of 20 minutes in a random order. At the end of each 20 minute period, data were collected. Up to six data sets were collected on each animal, a total of twenty nine data sets were analyzed. Effects of the frequency setting were tested using ANOVA with repeated measures.

Results: Mean $PaCO_2$ levels were lower when the ventilator was set at 5 Hz. No statistically significant differences were found for PaO_2, cardiac output (CO), pulmonary artery pressure (PA), or pulmonary vascular resistance (PVR).

Frequency (Hz)	$PaCO_2$ (torr)	PaO_2 (torr)	PA (mmHg)	CO (ml/min)	PVR (dyne-sec/cm^5)
12	42.7 ± 6.8 *	159.2 ± 25.4	18.8 ± 10.0	639.5 ± 197.7	3175 ± 3437
5	23.1 ± 3.7	191.7 ± 11.5	15.7 ± 6.9	653.6 ± 159.9	2297 ± 1971

(mean ± SD, *p< 0.001)

Conclusions: We have demonstrated that a lower HFOV frequency results in a predictable decrease in $PaCO_2$ by increasing tidal volume. However, this increase in tidal volume did not have the expected detrimental effect on hemodynamics.

OF-99-108

OPTIMIZING MEAN AIRWAY PRESSURE AT THE INITIATION OF HIGH FREQUENCY OSCILLATORY VENTILATION

Colleen Webster, RRT; Donna Tripp, RRT; Mike Gentile, RRT; Ira M. Cheifetz, MD. Divisions of Pediatric Respiratory Care and Critical Care Medicine, Duke University Medical Center, Durham, NC.

Introduction. The initial mean airway pressure (PAW) setting on high frequency oscillatory ventilation (HFOV) is often subjectively chosen by the clinician. The HFOV PAW is frequently set only slightly higher than on conventional mechanical ventilation (CMV). An initial HFOV PAW that is set too low may result in a prolonged time to achieve effective lung expansion and oxygenation. Thus, we hypothesize that the ideal initial PAW on HFOV should be higher than generally used.

Methods. A retrospective chart review of 41 infants and pediatric pts. ventilated with HFOV (Sensormedics 3100A) for acute lung injury was performed. Pts. ranged from 1 d to 16 yrs of age, and weights ranged from 2 to 93 kg. Measurements included PAW on CMV prior to HFOV, initial PAW setting on HFOV, and effective PAW (PAW corresponding to the best oxygenation within the 1st 12 hours). Additionally, the duration of time between the initial HFOV settings and its peak oxygenation effect (time initial) as well as the time between an increase to the effective PAW and its peak oxygenation effect (time effective) were recorded. Pts. were separated into two groups. Group A (n=14) contains pts. whose effective PAW represented an increase from the initial PAW on HFOV. Group B (n=27) contains pts. whose initial HFOV PAW and effective PAW were equal.

Results.

	CMV PAW	Initial HFOV PAW	Effective HFOV PAW	Time Initial (Hours)	Time Effective (Hours)
Group A	18.1 ± 3.7	22.0 ± 3.1	25.8 ± 3.4	4.7 ±3.3	7.3 ±3.9
Group B	20.6 ± 4.3	26.3 ± 5.5	26.3 ± 5.5	1.0 ± 0.0	4.4 ± 4.2
P Value	0.07	0.01	0.77	<0.0001	0.04

Conclusion. The most effective average HFOV PAW was an increase of 6 cm H_2O above CMV (Group B). Pts. whose initial HFOV PAW was <6 from CMV PAW required a second increase in their PAW to optimize oxygenation. This secondary increase led to a prolonged time to achieve optimal oxygenation (Group A). Our data suggest that the initial HFOV PAW in many pts. is set relatively low. However, care must be taken not to excessively increase PAW due to concerns of lung overdistention and secondary pulmonary injury.

OF-99-109

AUTOMATED LOW FLOW SYSTEMS TO MEASURE AND PLOT COMPLIANCE CURVES FOR MECHANICALLY VENTILATED PATIENTS.

Robert McConnell, RRT, Joseph Khoury, MD, Neil MacIntyre, MD, Duke University Medical Center, Durham, NC

BACKGROUND: Static pressure volume curves (SPVC) performed on mechanically ventilated patients with parenchymal lung injury may be a useful method to evaluate the critical lung opening pressures as well as potentially overdistending pressures/volumes. Indeed recent data (Amato - New Engl J Med Feb 1998) suggest that setting ventilator parameters according to these measurements reduces mortality. Unfortunately, SPVC measurements require a completely passive patient (requiring sedation or paralytics) and are combursome, time consuming and require patient removal from the ventilator. An alternative approach is the slow flow pressure volume curve technique (SFPVC). This measurement uses only a single lung inflation and, because inspiratory flow is very low (eg <10L/min), flow resistive pressures are minimized such that the resultant pressure volume plot mimics the SPVC. We evaluated two automated SFPVC methods incorporated into the software of a mechanical ventilator. PATIENT POPULATION: Mechanically ventilated adult patients that presented with ARDS (P/F ratios < 200) and bilateral infiltrates on chest x-ray were eligible for study. METHODS: Using a large volume graduated syringe (2.0L) equipped with a manometer and filled with 100% oxygen, patients received step-wise injections of volumes with measurement of the corresponding pressures (max $45cmH_20$) and a standard SPVC was plotted. Patients were then evaluated using the two automated SFPVC methods. The first (Bear 1000 t/es, Thermo Respiratory Group, Palm Springs, CA), allows the user to freeze and display the SFPVC using a clinician triggered volume assist breath (flow rate 10 L/min, FiO_2 1.0, PEEP 0, and tidal volume set to the max volume from the SPVC). The user can also elect to use tracheal (ie distal endotracheal tube) pressure to minimize flow resistive pressures. Markers indicate upper and lower inflection points and can be adjusted if necessary. Numeric values are displayed. The second (Venturi ventilator, Cardiopulmonary Corp, Milford, CT), has a feature known as Pflex, which functions independently of the set mode. Activation causes the suspension of normal ventilation and 2 consecutive slow flow breaths are delivered. The SFPVC plot is displayed. This device automatically subtracts endotracheal tube resistance effects in an attempt to eliminate flow resistive pressures. Markers indicating upper and lower inflection points can be adjusted if necessary. Numeric values are also displayed. RESULTS: Eleven patients had technically satisfactory SPVC and SFPVC tracings recorded (5 from the Bear 1000 t/es, 3 from the Venturi and 3 from both ventilators). Visual inspection of the compliance slope and the lower inflection points in 10 of the 11 patients revealed virtually identical SPVC and SFPVC tracings. In one patient, the SFPVC tracing on both ventilators was displaced slightly to the right of the SPVC tracing. CONCLUSION: These preliminary data suggest that automated SFPVC techniques may be acceptable substitutes for standard SPVC. Although patients must still have no spontaneous activity during SFPVC measurements, the fact that the technique requires only one to two inhalations and can be done in less than 1 minute make the procedure a much easier clinical measurement to perform.

OF-99-114

EVALUATION OF AUTOMODE IN THE SIEMENS 300A VENTILATOR

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Background: Weaning patients from mechanical ventilators optimally includes making frequent ventilator adjustments in response to the patients' needs. The Siemens Servo 300A mechanical ventilator proposes to allow the ventilator to be interactive with the patient needs, incorporating both control and support modes. We undertook the following experiment to validate the Automode algorithms in an animal model. **Method:** We ventilated six spontaneously breathing piglets in Pressure Regulated Volume Control/Volume Support (PRVC/VS), Pressure Control/Pressure Support (PC/PS) and Volume Control/ Volume Support (VC/VS). The animal was attached to a computerized respiratory monitor that recorded and analyzed individual animal breaths for response time, effort of triggering and work of breathing. Data collection was begun with the animals breathing spontaneously in each support mode. Succinylcholine was administered, inducing apnea, allowing the ventilator to switch between the modes automatically. Data collection was continued before, during and after apnea to observe the apnea delay time, trigger response time and any significant pressure or volume variances of the Automode feature. **Results:** We found no instances of failure of Automode to follow the predetermined algorithms. In each animal, there was a difference in both changes in pressure and most negative deflection of pressure by the animal during triggering in the post apnea phase (p<0.05). Response time in milliseconds for individual breaths was shorter from initial animal effort to most negative deflection of pressure during the post apnea phase (p<0.05). Total work of breathing was no different pre or post neuromuscular blockade during spontaneous breaths. **Experience:** It is our experience in the animal laboratory that Automode functioned as predicted. **Conclusions:** We conclude that differences in response time and negative deflection of pressure, as an indication of animal effort, were due to continued weakness from the neuromuscular blocker. However, the ventilator continued to trigger despite decreased effort by the animal.

OF-99-123

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THE EFFECT OF HELIOX DURING PRESSURE CONTROL VENTILATION THROUGH A FIXED RESISTANCE John Davies, BS, RRT, Robert McConnell, RRT, Mike Griffis, RRT, Neil MacIntyre, MD, Duke University Medical Center, Durham, NC

BACKGROUND/HYPOTHESIS: Helium is an inert gas that is 1/8 as dense as nitrogen. Mixed with oxygen (heliox), the density of helium reduces the resistance factor in gas delivery. This property has been shown to augment tidal volume delivery in patients breathing spontaneously who have increased airway resistance. Heliox also reduces the driving pressure required for a given tidal volume delivery with a volume targeted breath. With a pressure targeted breath, however, the reduction in gas density would be expected to increase tidal volume for a given set inspiratory pressure. METHODS: A bench study was designed with the Siemens Servo 900c (Siemens Medical Systems, Danvers, MA), a system in which volume measurement remains accurate in the presence of helium (Gentile et al, Respiratory Care abstract, Nov 98). Pressure assist control was used with the following settings: Inspiratory pressure of 14cmH$_2$O, PEEP 0 cmH$_2$O, inspiratory time percent 25%, respiratory rate 10. The ventilator was attached to an IngMar test lung and PMG 3000 graphics module (IngMar Medical, LTD, Pittsburgh, PA). The lung resistance setting on the test lung was set at 3 (corresponding to a resistance of 70 cmH$_2$O at 30 lpm). Tidal volumes were then measured using a conventional oxygen mixture and then with using increasing concentration of helium in oxygen. RESULTS: The results summarized in the table below show progressive increase in delivered tidal volume as gas density is reduced with helium.

Mixture	50% Oxygen	40% Oxygen	30% Oxygen	21% Oxygen
Balance Air	265 ml	262 ml	260 ml	259 ml
Balance H$_2$	327 ml	340 ml	350 ml	367 ml
Percent Increase	23%	30%	35%	42%

Conclusion: Heliox increases delivered tidal volume in a "dose dependent" fashion when using pressure assist control ventilation.

OF-99-159

INSPIRATORY PRESSURE-TIME CURVE DURING CONSTANT FLOW INFLATION PREDICTS VENTILATOR INDUCED LUNG INJURY (VILI).
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The static volume-pressure curve may be a valuable tool to minimize VILI in ARDS patients, however some limitations have been identified. As an alternative, the dynamic pressure-time curve found on most modern ventilators may overcome these limitations. The pressure profile at the airway opening (Pao) during constant flow inflation reflects changes in the elastic properties of the respiratory system. During tidal inflation, a straight Pao curve indicates that compliance (C) is constant (no stress), an upward concavity indicates progressive reduction of C (overdistension), and a downward concavity indicates progressive increase of C (recruitment-derecruitment). We hypothesized that continuous measurement of such profiles can be used to predict the development of VILI. Lung injury (PaO2/FiO2<100) was induced by saline lavage in 30 rats. The lungs were excised and ventilated with a constant inspiratory flow. Inspiratory Pao was continuously fitted to a power equation ($Pao=a \cdot t^b+c$) where "b" represents the shape of the curve. Peep(cmH20) and Vt (ml/kg) were set to obtain a "b" of 1 (straight line) and a lung recruitment maneuver was performed. The lungs were then randomized to 3 groups: recruitment/derecruitment (R/D)(b=0.1-0.3), no stress (b=0.9-1.2), and overdistension(OD) (b>1.5). The lungs were ventilated for 3 hours, then 1 lung was fixed with buffered formalin for morphologic examination and the other lung was lavaged for cytokine measurements (IL-6 and MIP-2)

	Vt	PEEP	Pplat	b	IL-6	MIP-2	Airway injury score
R/D	7±2	0±0*	25±2	0.3±0.03	3750±370*	1252±146*	36.7±9.3*
No stress	5±2	15±1	31±7	1.1±0.0	1632±245	511±71	5.7±2.0
OD	11±3*	13±2	65±11*	1.7±0.09	2758±379*	1016±181*	33.3±11.4*

*p<0.05 vs. no stress Values are means ±SE

Continuous monitoring and adjustment of the inspiratory portion of the dynamic pressure-time curve can be used to set ventilatory settings which minimize VILI..
MRC Canada and CNR Italy

OF-99-156

Auto-Mode: Is it Really That Simple?
Richard Lawhead, BS, RRT, CPFT, P/P Spec.,
K.S. Anand, MBBS, D.Phil., Arkansas Children's Hospital

Background: Siemens Servo Ventilator 300A has a closed loop ventilation feature called Automode. Automode allows the ventilator to automatically switch between a control mode of ventilation and a spontaneous mode when certain parameters are met. Two consecutive triggering efforts from a patient will change the ventilator from a control mode to a spontaneous mode. If the patient stops breathing for a pre-determined period of time, the ventilator automatically switches back to a control mode (5sec for neonate; 8sec for pediatric; 12sec for adult).

Discussion: We report a patient who was managed initially with PRVC/VS Automode. The patient is a 10yr, 41kg male who was intubated and admitted to the PICU with the diagnosis of pneumonia. The patient was placed on the SV 300A ventilator with the following settings: PRVC 20/Vt 300/35%/+10. The patient selector had to be placed in the adult mode secondary to the flow limitation of 33 lpm in the pediatric setting. The Automode function was initiated at the beginning of Day 2. During the patient's stay on the ventilator, the ventilator settings often had to be manipulated in the attempt to manage Automode effectively. When the patient's RR was below the CMV rate, the Vt and PIPs increased substantially. The CMV rate was reduced to combat this. However, when the patient automatically switched back into PRVC, the lower rate was not sufficient to maintain adequate blood gases. After many manipulations, the Automode function was finally turned off and the patient successfully weaned and extubated utilizing PRVC and VS managed more conventionally.

Time	pH	pCO2	pO2	RR	Vtset	Vtdel	PIP	Mode
Day 2 @ 0030	7.25	81	80	12	255	390	36	Auto-VS
Automode turned OFF (Day 2 @ 0100)								
Day 2 @ 0600	7.36	59	92	20	300	300	29	PRVC
Automode turned ON (Day 2 @ 0830)								
Day 2 @ 1200	7.30	64	87	20	300	300	32	Auto-PRVC
Day 2 @ 1500	[redacted]	[redacted]	[redacted]	12	300	440	40	Auto-VS
Day 2 @ 1630	[redacted]	[redacted]	[redacted]	20	300	300	30	Auto-PRVC
Day 2 @ 1800	7.32	61	104	14	300	450	42	Auto-VS

Conclusions: The simplistic mechanism used to switch patients between control and spontaneous modes of ventilation and the multiple functions of the CMV rate knob may increase difficulty in the ventilator management of sick children with Automode on.

OF-99-163

CASE PRESENTATION IN THE USE OF THE 3100A OSCILLATOR IN ARDS.

Thomas Serrano, RCP,BS RRT, Mark Harris, RCP, RRT, Andy Bogy, RCP,RRT,Tony Marquez, RCP,CRTT, Mark Tamondong, RCP, CRTT, David Harris, MD, Mukesh Shah, MD. Presbyterian Intercommunity Hospital, Whittier, California.

This is a case presentation of a 48-year-old female who has a known case of Cerebral Palsy and seizure disorder. She presented to the emergency room with a chief complaint of abdominal pain. Subsequently, the patient underwent repair of a volvulus because of a large bowel obstruction. Postoperatively the patient was doing well and was sent to the general floor. The next day the patient presented with gurgling sounds because of upper airway secretion, although no respiratory distress was noted. The CXR showed no acute changes and her SpO2 was 95% on 3L/m NC. Two days later the patient was transferred to ICU due to increase O2 requirements, bronchial hygiene issues and seizure activity. The patient continued to improve after 5 days in ICU and was transferred to the general floor. The day after transfer the patient exhibited respiratory distress and increase WOB. Patient was tracheal suctioned for large amounts of bile material, subsequently was transferred back to ICU. ABG on 50% was PaO2 69 PaCO2 34 pH 7.43 BE –1.6 HCO3- 24 RR 40's. The patient was electively intubated and placed on Vt 700 PEEP 5 Fio2 47% AC 10 with a spontaneous rate of 17. Over the next 2 days the patient continued to deteriorate requiring sedation and paralyzation with increase ventilatory support. She was eventually placed on inverse ratio ventilation of 4:1 with MAP at 29 cmH2O, Vt 568 RR 12 Peep 10cwp Fio2 60%. On these setting the patient ABG was PaO2 48 Paco2 68 pH 7.20 BE 1.0 HCO3- 23.7. CXR showed diffuse air-space consolidation especially RLL. Hemodynamic support was achieved with dopamine at 18.9 mcg/kg/min for a BP of 100/50. Pcwp 14 Pulmonary Artery Pressures 40/22. Oxygen Index was 31 (Fio2 x MAP x 100/PaO2) on inverse ratio ventilation. After a lengthy discussion it was decided to initiate High Frequency Oscillator Ventilation (HFOV) via Sensormedic 3100A. Transcutaneuos monitoring was initiated and was allowed to stabilize prior to placing pt on HFOV. Initial Setting on HFOV were MAP 32cm H2O Inspiratory Time 33% Hz 9 FiO2 1OO% and Delta P 45. The initial Delta P revealed minimal chest vibration and was rapidly increase until chest vibration was improved and TcCo2 ceased to increase. The initial ABG on HFOV was PaO2 71 PaCO2 76 pH 7.20 BE 1.0 HCO3- 23.7 on MAP 32cmH2O Hz 9 Inspiratory Time .33% Delta P 65 Fio2 68% TcCO2 81. One hour after initiating HFOV a CXR was obtained which showed interval clearing of bilateral air space consolidation. The ABG results were PaO2 63 PaCO2 66 pH 7.27 BE 2.7 HCO3- 25.6 on MAP 32 inspiratory time 33% delta P 69 Hz 6 Fio2 65%TcCO2 68 OI 33. Dopamine drip was titrated at 18.9 mic/kg/min, BP 110/60, PAP 46/28 Pcwp 18. CXR continued to show improvement with total expansion of right lung. ABG results were PaO2 56 PaCO2 41 pH 7.49 BE 7.5 HCO3- 31 on MAP 28 inspiratory time 50% delta P 60 Fio2 45% OI 22. On the third day of HFOV the patient began to have mucus plugging with resultant intermittent difficulty in patient ventilation. Conclusion: What we demonstrated is that HFOV was beneficial in achieving lung volume recruitment, which resulted in total expansion of right lung within a short period of time. The FiO2 was lowered to 38% prior to developing mucus plugging with a MAP of 20. Hemodynamically, dopamine administration was titrated down from 18.9 mic/kg/min to as low as 3.7 mcg/kg/min. We discovered that secretions or more importantly secretion removal is an obstacle when using HFOV in adults. The design of the inline suction catheter connection, which is at a 90-degree angle, interferes with the ability to oscillate the patient. Removal of the inline suction catheter was necessary. Frequent disconnection from the oscillator, for suctioning may have resulted in alveolar collapse.

OF-99-181

VALIDATION OF A SIMPLE METHOD FOR ESTIMATING SIMULATED TOTAL PATIENT WORK OF BREATHING USING A MECHANICAL LUNG MODEL.

David C. Shelledy, PhD, RRT, Lori A. Moreno, BS, RRT and Kimberley A. Cooke, BS, RRT. The University of Texas Health Science Center at San Antonio, San Antonio, Texas.

BACKGROUND: Methods have been developed to measure patient trigger work, spontaneous work of breathing (WOB) and machine work of breathing during mechanical ventilation. Methods for assessment of spontaneous WOB may not include work to expand the thorax and require measurement of esophageal or pleural pressures. Further, the measurement of patient WOB during mechanically supported breaths in the presence of spontaneous breathing efforts remains problematic. One approach to assess patient WOB during a mechanically supported breath in the presence of active inspiratory efforts is to compare differences in the patient's pressure-volume curves during apneic and active breathing. Methods to assess WOB in mechanical lung models have generally been limited to the measurement of trigger work, machine work and imposed work of breathing. We developed and assessed a simple method to estimate total "patient" work of breathing (TPWOB) while using a two-compartment lung model to simulate spontaneous breathing. If reliable, such a method could be used for research purposes to compare TPWOB during spontaneous and mechanically supported breaths in the presence of simulated spontaneous breathing in the laboratory setting. **METHOD:** Spontaneous breathing was simulated using a two-compartment mechanical lung model (Michigan Instruments, Inc., Grand Rapids, MI). Initially, work to passively inflate compartment A (WOB_A) was determined for normal compliance and resistance (C_{TOT} = .05 L/cmH2O, Raw = 2.7 cmH2O/L/sec), decreased compliance (C_{TOT} = .02 L/cmH2O) and increased resistance (Raw = 17.6 cmH2O/L/sec). Measures were repeated at tidal volumes of 200 – 1200 ml in 100 ml increments with a peak flow of 60 L/min and a sine wave flow pattern provided by a Puritan Bennett 7200. WOB to inflate the test lung was determined using the VenTrak 1550 Respiratory Mechanics Monitoring System (Novametrix Medical Systems, Inc., Wallingford, CT). This procedure was repeated to determine the WOB to mechanically inflate lung model compartment B (WOB_B). Spontaneous breathing was next simulated by using the Puritan Bennett 7200ae to drive compartment B while linked to compartment A (WOB_{A+B}) and the work to inflate compartment B (WOB_{A+B}) was measured under all test conditions. Simulated spontaneous TPWOB was then calculated as follows:

$$TPWOB = WOB_{A+B} - WOB_B$$

Calculated TPWOB was compared to measured WOB_A using the t-test for dependent samples. A Pearson-product correlation and regression equation were calculated to determine the slope and intercept of the regression line for paired values for TPWOB and measured WOB_A. **RESULTS:** There was a significant correlation ($r = .97$, $p = .00001$) between TPWOB calculated and WOB_A measured. The regression equation was: TPWOB= .0756+ .6015 x WOB_B. Means (SD) for TPWOB and measured WOB_A were 1.11(.4) and 1.72(.65) J/L ($t = 20.5$; $p = .0001$). **CONCLUSION:** There was a small, but statistically significant difference between TPWOB and measured WOB_A. Calculated TPWOB correlated well ($r = .97$) with measured WOB and may provide a useful laboratory method to assess the efficacy of different methods for providing mechanical ventilatory support during simulated spontaneous breathing.

OF-99-196

A COMPARISON OF THE EFFECTS OF PRESSURE-TRIGGERED DEMAND FLOW, FLOW-BY, PRESSURE-TRIGGERED PRESSURE SUPPORT AND FLOW-TRIGGERED PRESSURE SUPPORT ON TOTAL WORK OF BREATHING IN A LUNG MODEL.

David C. Shelledy, PhD, RRT, Kimberley A. Cooke, BS, RRT and Lori A. Moreno, BS, RRT. The University of Texas Health Science Center at San Antonio, San Antonio, Texas.

BACKGROUND: Pressure-support (PS) and Flow-by (FB) have been advocated as methods to reduce patient work of breathing during mechanical ventilation. While patient trigger work and spontaneous work of breathing are relatively easy to determine, the actual total patient work performed during a mechanically supported breath can be difficult to ascertain. We compared simulated total patient work of breathing (TPWOB) during pressure-triggered demand flow (PTDF), flow-by (FB), pressure-triggered pressure support (PTPS) and flow-triggered pressure support (FTPS) using the Bennett 7200ae ventilator and a lung model using an indirect method for estimating TPWOB. **METHOD:** Spontaneous breathing was simulated at a respiratory rate of 10 bpm and a tidal volume of 500 ml with a peak flow rate of 60 L/min and a sine wave flow pattern using a two-compartment mechanical lung model (Michigan Instruments Inc., Grand Rapids, MI). For PTDF, the test ventilator was set at a sensitivity of -0.5, -1.0, -1.5 and -2.0 cmH_2O, PEEP/CPAP = 0 cmH_2O. For FB, settings were 6/3, 6/2, 6/1, 10/3, 10/2, 10/1 L/min. for base flow and flow sensitivity, PEEP/CPAP = 0 cmH_2O. For PTPS and FTPS, pressure support was set a 5, 10, 15, and 20 cmH_2O with the sensitivity and FB settings varying as described for PTDF and FB, abuve. TPWOB was determined using the VenTrak 1550 Respiratory Mechanics Monitoring System (Novametrix Medical Systems, Inc., Wallingford, CT) as follows:

TPWOB = WOB driver compartment linked to – WOB driver compartment alone
spontaneous compartment

For each condition, TPWOB was estimated for normal compliance (C_{TOT} = .05 L/cmH_2O, Raw = 2.7 cmH_2O/L/sec), decreased compliance (C_{TOT} = .02 L/cmH_2O) and increased resistance (Raw = 17.6 cmH_2O/L/sec). **RESULTS:** TPWOB ranged from .71 to 1.33 J/L for PTDF and .56 to 1.13 J/L for FB. TPWOB ranged from 0 to 1.04 J/L for PTPS and 0 to 1.05 J/L for FTPS. Under all conditions for PT, as sensitivity increased, TPWOB decreased and as PS increased, TPWOB decreased. Table 1 compares the mean TPWOB for all conditions by mode.

Total Work of Breathing (J/L) -- Mean (SD)				
	Normal	↓ Compliance	↑ Resistance	All Conditions
PTDF	1.73(.06)	1.23(.05)	1.11(.05)	1.06(.22)
FB	1.52(.01)**	1.12(.002)**	.90(.007)**	.87(.23)*
PTPS	.15(.19)	.66(.27)	.53(.26)	.44(.32)
FTPS	.11(.17)	.60(.29)	.43(.27)	.38(.32)

* significantly less than PTDF ($p = .03$) ** significantly less than PTDF ($p < .0001$)

There were significant differences between PTDF and FB ($p < .05$) prior to the addition of pressure support. There were no significant differences between PTPS and FTPS ($p > .05$). **CONCLUSION:** In the absence of pressure support, flow-by produces a small decrease in TPWOB. Flow-by combined with pressure support offered little advantage over traditional pressure-triggered pressure support ventilation in reducing simulated TPWOB.

OF-99-195

ABSTRACT

A BENCH TEST STUDY OF A TRANSPORT VENTILATOR; "IT'S THE LITTLE FOXES THAT SPOIL THE VINE"

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OBJECTIVE: To determine the effects of exhaled tidal volumes with the addition of PEEP as compared to SET and Delivered volumes. This study was triggered from discrepencies observed during routine calibrations and patient care on fixed-wing transport.
METHOD: A bench test of 3 of our Crossvent CV-4 ventilators in its assigned aircraft using the same circuit, pneumotach, test lung and respirometer for all tests. Tests were conducted with the aircraft on the ground and cabins unpressurized. All measurements were taken after Calibration of circuit compliance and pneumotach as required by manufacturer and company Policy. Volumes measured included Set Tidal Volume, Corrected Tidal Volume, Exhaled Volume by pneumotach and Delivered Tidal Volume by respirometer. Measurements were taken with 0cm PEEP, +3cm PEEP and +5cm PEEP. Volumes were 300cc, 500cc and 700cc Set. Flows were adjusted to maintain an I:E ratio of 1:4.
RESULTS: In the controlled setting with all other parameters being equal; Rate 12, FiO2 100%, I:E Ratio 1:4, Auto Shift 15sec and Sensitivity -2cm. The following changes ocurred with PEEP. For set Tidal Volume of 300c, flow of 20 l/m and with 0cm, +3cm and +5cm PEEP, exhaled tidal volumes increased 1.4% - 3.7% with 0cm PEEP but decreased 6.7% with 3cm and 7.8% with 5cm PEEP. For tidal volumes of 500cc and flow of 30 l/m, exhaled tidal volumes decreased 2.8%, 9.0% and 9.6% respectively. For tidal volumes of 700cc with flows of 40 l/m exhaled tidal volumes decreased 9.7%, 11.4% and 11.5% respectively. **CONCLUSION:** The data suggests that when adding PEEP it is imperative to check and monitor the exhaled tidal volumes and not corrected delivered volumes. More importantly Set tidal volumes need to be adjusted in order to ensure adequate ventilation has occurred especially if end-tidal C02 is not available.

OF-99-239

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ROLE OF DUAL ONE-WAY VALVE "T" ADAPTER AND TRACHEAL GAS INSUFFLATION (TGI) IN MANAGING CERVICAL SPINAL CORD INJURY PATIENTS WITH TRACH TUBE CAP INTOLERANCE. A PRELIMINARY REPORT.

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Introduction: In the process of weaning from mechanical ventilator or trach tube, patients with cervical (C3-C5) spinal cord injuries (SCI) may undergo trach tube capping. Selected SCI patients may not tolerate trach tube capping due to an associated increased work of breathing. Four trach tube cap configurations were compared with a conventional trach tube cap to determine if any configuration enabled SCI patients with trach tube cap intolerance (TTCI) to experience significant improvements in RR, EtCO2, SpO2 and HR. Improvement in these measures was considered an important first step enabling patients to gradually tolerate increased work of breathing associated with placement of a conventional trach tube cap.

Methods and Materials: Cervical SCI patients (n=5) with 8-mm-ID (Portex) trach tube were deemed ready for trach tube cap placement by their ability to maintain HR < 120, RR < 30, SpO2 > 92% on 28% O2, and minimum VT 400 cc while on CPAP 5 and PSV 5 via mechanical ventilator (Purtian Bennett PB 7200a) for 24 hours. Prior to clinical trial, patients received tracheal suctioning, hyperinflation, bronchodilator via MDI, deflation of cuff and decannulation of inner cannula. Patients who exhibited TTCI (RR > 30 and / or VT < 350) during previous trach tube cap placement (control), received the following sequence of trach tube cap configurations:

Configuration 1) single one-way valve + 2 l/m O2 NC 10 minutes
Configuration 2) dual one-way valve + 2 l/m O2 NC 10 minutes
Configuration 3) single one-way valve + 2 l/m O2 TGI 10 minutes
Configuration 4) dual one-way valve + 2 l/m O2 TGI 10 minutes

RR, EtCO2, SpO2 and HR were measured for each configuration. After trial, patients were returned to previous vent settings. Data were analyzed by Repeated Measures ANOVA and Bonferroni t-test.

Results: When compared with conventional trach tube cap, all configurations resulted in lower ($p < 0.05$) RR. Configuration 4 resulted in lower ($p < 0.05$) EtCO2. Configurations 3 and 4 resulted in higher ($p < 0.05$) SpO2. HR, dyspnea ratings, resistance of devices, and trans tracheal tidal airway pressures were not significant.

Conclusion: In SCI patients with TTCI, only configuration 4, a dual one-way valve U/Adapit "T" Adapter (Baxter) + 2 l/m O2 TGI, was associated with significant improvements in RR, EtCO2, and SpO2. Continued use of this configuration enabled patients to eventually tolerate workload associated with trach tube cap. OF-99-001

MEASUREMENT OF ENDOTRACHEAL TUBE LEAK TO PREDICT POST-EXTUBATION STRIDOR AND NEED FOR REINTUBATION.

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Introduction: The purpose of this study was to determine the predictive value of an endotracheal tube cuff leak on the development of stridor and the need for reintubation. **Methods:** Consecutive trauma patients who required intubation at a Level I trauma center from 7/97-7/98 were prospectively studied. Pediatric patients and those who did not meet the standard weaning protocol criteria established by our Division were excluded. Injury severity score (ISS), endotracheal tube size, reason for intubation, and days intubated before initial extubation attempt were recorded. At the time of extubation, the difference in actual tidal volume (TV) between pre- and post-endotracheal tube cuff deflation was calculated. This number was then divided by the pre-cuff deflation TV and recorded as the % cuff leak. Patients were followed after extubation for the development of stridor or the need for reintubation. Statistical analysis was performed using Chi-square. **Results:** Of the 114 patients analyzed, the most common reason for intubation was closed head injury (48%). 14 patients (12.2%) developed stridor (mean cuff leak = 11.7%), 5 (4.4%) of whom required reintubation (mean cuff leak = 11/0%). The mean cuff leak was 58.3% for the remaining 100 patients ($p<0.05$). Patients who developed stridor or were reintubated had been intubated for a significantly greater length of time than those not developing stridor or requiring reintubation (6.6 vs 3 days). There were no differences in ISS, endotracheal tube size, or reason for intubation between these groups. **Conclusions:** We conclude that the degree of cuff leak (< 11.7%) is useful in identifying patients at risk for developing stridor and/or requiring reintubation. It also appears that the length of intubation prior to the initial extubation attempt correlates with the amount of cuff leak.

OF-99-015

COST EFFECTIVENESS OF DECREASING THE FREQUENCY WITH IN-LINE SUCTION CATHETER CHANGES,

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Case Report: One of the most frequently utilized procedures surrounding mechanical ventilation is endotracheal suctioning. While this care modality is considered routine to the respiratory care practitioner and other healthcare professionals, it remains an essential supportive treatment to providing appropriate patient care. Using the research published in 1997 by Kollef[1] as a model, a six-month pilot evaluation was performed in the Medical Intensive Care Unit (MICU) at our university-affiliated teaching institution in 1998. Data that was evaluated included supply cost relationships; ventilator acquired pneumonia (VAP) rates and ventilator days while employing a protocol-driven system of in-line catheter utilization. In early 1998, after review of the literature, a multidisciplinary team was formed that comprised representatives of the medical staff, pulmonary services, infection control and quality improvement departments. An in-line suction catheter protocol was developed with associated monitoring for comparison to previously institutional-based benchmarked infection control VAP data. The hypothesis was that the less often the more critically ill patient ventilator circuit was interrupted, the lower the incidence of acquiring VAP. The frequency was decreased from daily to weekly and as needed as specified by a patient care protocol specific to diagnosis, secretion volume and ventilator settings. The protocol would immediately terminate and revert to pre-study practices if VAP benchmark was exceeded. The study used April 1998 VAP data as benchmark and study period was six months. We found that even with a increase in ventilator days, decreasing the frequency of in-line suction catheter exchanges had a marked impact on operational expense while maintaining or decreasing VAP for a adult critical care unit. Study period expense for the daily in-line catheter exchange was $5,186. Projected expense for the same period is $14,076. Actual study expense minus projected catheter use for the same period demonstrated a 63% reduction or cost savings of $8,890. Actual expense for single-use catheters during the same period was $782. Overall cost-effectiveness may vary based on in-line suction catheter negotiated prices, group purchasing contracts or other sources that address bulk contracting of supplies. Protocol modification to meet existing institutional requirements may further impact program outcomes. We recognize that more research on this topic is required but this pilot analysis supports that elimination of routine suction catheter changes is safe and reduces costs associated with providing mechanical ventilation without negatively impacting patient care outcomes.

1998 Catheters	*Apr***	May	Jun	Jul	Aug	Sept	Oct	*Total*	*Avg/Ma*
In-Line									
Volume	***190***	90	90	60	60	60	60	**420**	**70**
Expense	***$2,346***	$1,111	$1,111	$741	$741	$741	$741	**$5,186**	**$864**
Single-Use									
Volume	***0***	---	---	---	---	---	---	**1,899**	**316.5**
Expense	***0***	---	---	---	---	---	---	**$782**	**$130**
Ventilator Days	***153***	183	210	163	131	133	161	**981**	**191**
VAP Rate	***19.61***	10.93	0	19.61	15.27	7.52	18.63	**N/A**	**10.28**

**Benchmark Data

1. Kollef, M.H., Prentice, D., Shapiro, S.D., Fraser, V.J., Silver, P.,Trovillion, E.,Weilitz, P., Von Hartz, B., St. John, R., 1997. Mechanical Ventilation with or without Daily Changes of In-Line Suction Catheters. Am J Respir Crit Care Med. 156:466-472

OF-99-009

REDUCTION OF LABOR HOURS WITH APPROPRIATE SELECTION OF ENDOTRACHEAL TUBE FIXATION DEVICE

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BACKGROUND: Reapplication of any endotracheal tube (ET) fixation device, to prevent accidental extubation, is time-consuming. A previous study showed that the Neobar was superior to a conventional taping method in a number of ways. The Neober is a small plastic arch with adhesive cheek pads designed to secure a pediatric patient's ET. The study showed that the Neobar was better regarding ease of application, ability to perform mouth care, reduction of skin irritations, and verification of ET placement. There was also a reduction in the incidence of accidental extubations (Respir Care 1998; 43(10) :840.) However, device reapplication was not studied. We hypothesize that the use of the Neobar, compared to conventional tape, would reduce the time-consumed with fixation device reapplication in order to keep the ET secure child's face for the duration of mechanical ventilation. **METHODS:** This pilot study enrolled children from our Pediatric Intensive Care Unit requiring intubation and mechanical ventilation for greater than 24 hours. The hydrocolloid adhesive on the cheek pads of the Neobar was applied to dry skin without additional fixatives. A piece of adhesive tape was used to secure the ET to a vertical bar on the arch. The conventional taping method required the application of tincture of benzion to the area of the upper lip prior to the application of a piece an extra-thin strip of Duoderm to the cheeks on either side of the nares. The top portion of a pre-cut "y" shaped piece of one-inch cloth tape was placed over the upper lip with the end affixed to the Duoderm. The bottom end was affixed to the ETT by wrapping it around the tube in a spiral fashion. This procedure was repeated with a second and third piece of tape. Total time consumed with reapplication was defined as the product of standardized device application time and the number of reapplications per ventilator day (Neobar = 5 minutes; tape = 15 minutes). Patient age, weight, gender, ET size and securing device, restraint use, number of reapplications and accidental extubations were recorded. Distributions of labor time, and demographics between groups were compared by paired t-test. **RESULTS:** The groups were similar in terms of demographics, ET size, use of physical restraints and/or sedation, $p > 0.50$. One accidental extubation occurred in each group. Not all patients required reapplication of the endotracheal tube fixation device. Outcome data below are mean ± standard deviation:

	Neobar	Tape	p-Value
Number in Study	8	11	-
Reapplications/ventilator day	0.38 ± 0.29	0.64 ± 0.81	0.35
Total time (minutas/ventilator day)	1.97 ± 2.0	5.73 ± 3.8	0.05

CONCLUSIONS: The number of reapplications was not different between the two devices. However, the labor time spent on reapplication of the conventional tape method was almost three times longer than the Neobar.

OF-99-040

AN AGGRESSIVE CHEST PHYSIOTHERAPY TECHNIQUE IN ACUTE LOBAR COLLAPSE IN ELEVEN PATIENTS WITH AN ARTIFICIAL AIRWAY

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General clinical practice suggests the performance of CPT as percussion and postural drainage q4hr for 24-48 hours before alternative therapy is employed in acute lobar collapse. An alternative approach was utilized in patients with artificial airways (endotracheal /tracheostomy tubes) using a combination of ipsilateral hyperinflation, percussion and postural drainage with bronchial lavage. The purposes of the technique were to maintain patient safety, decrease therapy utilization time with associated cost savings, normalize pulmonary mechanics and prevent bronchoscopy. Eleven patients with radiograhic evidence of acute lobar or greater collapse assumed due to mucoidal plugging were administered this approach with permission of the Medical Director. The patients were appropriately positioned and placed in trendelenburg. Increased tidal volumes to the range of sigh breaths (1.5x Vt) were utilized with PEEP application at 5 to 10cm/H2O. PAP was maintained as close as possible to ≤ 40 torr. Respiratory rates were established at 8 -12/min. The FIO2 was increased as needed to maintain an SPO2 ≥ 95% throughout the procedure. Breaths were administered either by mechanical or manual ventilator. Percussion was performed to the affected region no less than 20 minutes with suctioning performed as indicated (coughing, rbonchi, increased PAP) through the artificial airway. If the airway secretions were minimal in volume or moderately tenacious bronchial lavage with a 4.0% solution of NaHCO3 was utilized in 10 -15 cc aliquots. Patients were monitored utilizing RR, continuous SpO2, Cst, Raw and PAP measurements pre/post when possible, breath sounds, cardiovascular stability, spontaneous Tv and pre/post radiographs. **The results demonstrated in all eleven patients essentially complete reexpansion of the affected area.** Post procedure the SpO2 moderately increased on previously established FIO2's, no significant changes in Raw, increased compliance, increased aeration throughout the affected area, increased spontaneous Tv on previously established PSV, spontaneous respiratory rates did not significantly change. This modification of traditional CPT strongly suggests effectiveness and safety as there were no adverse effects or complications (volutrauma, airway plugging, decreased SpO2, severe cardiac instability, change in mental status, or respiratory distress). Three patients eventually were bronchoscoped due to recollapse of the affected region. This one time procedure lasted approximately a continuous hour. Cost savings are institutionally related to total bronchoscopic costs and/or the institutional charges for multiple CPT, suctioning and therapist times.

OF-99-099

EVALUATION OF THE EFFECT OF ENDOTRACHEAL TUBE LEAK ON THE PERFORMANCE OF THE HAMILTON GALILEO VENTILATOR IN THE ADAPTIVE SUPPORT VENTILATION MODE IN THE PEDIATRIC SETTING

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Background: We evaluated the response of the Hamilton Galileo ventilator in the adaptive support ventilation (ASV) mode at four patient weight settings to increasing percentages of endutracheal tube leak.

Methods: A Hamilton Galileo ventilator operating in the ASV mode was attached to a DB&M Products Infant Lung Simulator. Ideal body weights (IBW) from 5 to 20 Kg in increments of 5 Kg were set. An appropriate size endotracheal tube was selected for each weight. A V% setting of 100 per cent, PEEP of 5 cm H_2O, and lung/thorax compliance of 3 mL/cm H2O were maintained. An adjustable valve was placed distal to the ventilator/endotracheal tube connection to simulate leaks. A heated wire pneumotach was placed between the ventilator and the endotracheal tube connections to measure leak percentage. Leaks from 10 to 50 per cent were evaluated in 5 per cent increments. Delivered and exhaled tidal volumes were measured distal to the leak using a pressure differential pneumotach. We evaluated the actual value and percentage change from baseline value of expired tidal volume and minute volume distal to the leak for each IBW setting, endotracheal tube size, and leak percentage. P value was calculated at each leak increment fur the decrease in expired minute volume from the baseline value.

Results: At an IBW setting of 5 Kg, minute volume did not decrease significantly from the baseline value ($P \geq 0.05$) at leaks as high as 50 per cent. At IBW settings of 10, 15, and 20 Kg, minute volume began to show significant decrease ($P \leq 0.05$) at 35, 25, and 20 per cent leaks respectively. Therefore, proportionally larger decreases in expired minute ventilation were noted at larger IBW settings for a given percentage of leak.

Conclusions: For a patient weight range up to 15 Kg and an endotracheal tube leak less than or equal to 25 per cent, minute ventilation decrease in the ASV mode was not statistically significant. In patients whose IBW is 5 Kg, minute volume was statistically unaffected by leaks as high as 50 per cent. Although clinical investigation is warranted, ASV may be a desirable mode in small pediatric patients with a sizeable endotracheal tube leak.

OF-99-107

UTILIZATION OF A TRACHEOSTOMY WEANING PROTOCOL IN THE ACUTE REHABILITATION HOSPITAL

William M. Barnes Jr. BA, RN, RRT; Richard C. Warner MS, RRT;
and Joshua Krassen DO

Abstract

Background; This study evaluated the use of a tracheostomy weaning protocol related to the success of decannulization in the acute rehabilitation hospital. The study examined individuals with spinal chord injuries (SCI), traumatic brain injury (TBI), neuromuscular dysfunction (NMD) and ventilator dependent respiratory failure (VDRF). Most individuals had no prior pulmonary history but required mechanical ventilation during the initial stages of their injury. The patient population was between the age of 9 and 84 with a mean age of 49. A multi-skilled inter-disciplinary team approach was established. The team was composed of a physician, nurse practitioner, primary nurse, respiratory care practitioner (RCP), and speech and language therapist (SLT). **Method;** Patient were admitted to the rehabilitation facility for tracheostomy weaning. Either a cuffed (80 clients) or uncuffed tracheostomy tube (13 clients) were present from the referring hospital. This study was concerned only with the total length of time for decannulization. Data was collected on 93 patients during an 18 month period.

1. Candidates for decannulization were identified and the "Tracheostomy Weaning Protocol" was ordered by the physician.
2. The RCP and SLT implemented the protocol, steps include:
    a. evaluated each patient for high-risk decannulization
    b. determine the need for an ENT consult.
    c. downsize tracheostomy was downsized to #5 or #6 metal tracheostomy dependent on patient need.
    d. once the metal tracheostomy has been downsized to #5, begin plugging trials with observation QID. Extend trials to all day as tolerated
    e. tracheostomy collar humidification H.S..
    f. once downsized to #4 metal tracheostomy and plugged, consider decannulization with physician's approval.
    g. Decannulate and evaluate decannulization tolerance
    h. Perform stoma care and evaluate stoma closure.
3. Protocols are held for signs and symptoms of respiratory distress due to upper airway obstruction, increased secretions and/or aspiration.

Results: Of the 93 tracheostomy patients evaluated, 93.5 % qualified within the tracheostomy weaning protocol parameters. The remaining patients 6.5% were disqualified based on multiple complications such as prolonged inability to protect upper airway and continued ventilator support. !00% of those individuals that qualified for decannulization, were successfully weaned within 50 days. The average decannulization for uncomplicated tracheostomy (less than 21 days) was 10.246 days which represents 74% of the weanable population. **Conclusion;** Base on our finding, a tracheostomy weaning protocol utilizing the team approach can improve the rehabilitative capacity of the patient. This is accomplished by accelerating the decannulization process, improve communication and therapy participation and reducing nosocimial infection thus decreasing hospitalization cost.

OF-99-110

EXTRACORPOREAL LIFE SUPPORT IN A PATIENT WITH ACUTE LUNG INJURY AND PULMONARY AIR LEAK REFRACTORY TO UNCONVENTIONAL SUPPORT.

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INTRODUCTION: Patients with Acute Lung Injury (ALI) and pulmonary air leak are at a very high risk for morbidity due to irreversible lung injury. An Oxygenation Index (OI) of >25 is associated with a 50% mortality rate and an OI of >40 correlates to 80% mortality. One method of supporting patients with ALI and airleak is Extracorporeal Life Support (ECLS).

CASE SUMMARY: This is the case study of a 9.6 kg, 18-month-old female who ingested an unknown quantity of ginseng oil hair tonic. She was seen in the local ER where she had a normal chest radiograph, was treated with a cough suppressant and discharged to home. Two days later, she was readmitted with worsening respiratory distress and increased work of breathing. At that time she was diagnosed with a right pneumothorax which required chest tube placement and over the next 24 hours she developed a pneumomediastinum. On day two, the child required endotracheal intubation due to her deteriorating status and was placed on conventional mechanical ventilation. Initial conventional ventilator settings: PIP 38, PEEP 12, Rate 12, FiO_2 1.0, I:E ratio 2:1. Arterial blood gas (ABG) results were pH 7.26, PaO_2 131, $PaCO_2$ 50. Respiratory failure progressed and on day 3 the patient was placed on a Bunnell Life Pulse jet ventilator at a rate 420, I-time 0.02 seconds, PIP 41, PEEP 14, MAP 19.6, FiO_2 1.0. On day 4, due to decreasing saturations the patient was placed back on conventional mechanical ventilation at rate 12, PIP 34, MAP 23, I:E ratio 1.5:1. ABG results were pH 7.46, PaO_2 67, $PaCO_2$ 38, with an OI of 34. On day 5 she was placed on a Sensormedics 3100A high frequency oscillator ventilator. Settings were Hz 10, Map 32, Amp 75 with ABG revealing pH 7.10, $PaCO_2$ 104, PaO_2 104 and OI 31. The patient was placed back on CMV at PIP 35, PEEP 12, MAP 26, FiO_2 1.0, rate 12, and I:E ratio 2:1. ABG results revealed pH 7.34, PaO_2 68, $PaCO_2$ 54,and OI 48. Shortly afterwards she was transferred to Duke University Medical Center. On arrival to the Pediatric Intensive Care Unit the patient was placed on Venous-Arterial ECLS. During the next 10 days she was maintained on a flow of 100 cc/kg until her air leak resolved and ARDS improved. She was then cycled off pump and successfully extubated 14 days later.

DISCUSSION: Determining failure of unconventional support is difficult and requires continous observation and reevaluation. While the use of high frequency oscillator and jet ventilation are usually considered in cases of ALI and air leak, this case demonstrates that ECLS is an effective therapy and should be considered early when alternative modes of ventilation are failing to improve the respiratory status.

OF-99-119

EVALUATION OF PULMONARY FUNCTION TESTS IN TRACHEOSTOMIZED PATIENTS

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Background: When the upper airway is bypassed respiratory complications are common in patients who are managed with tracheotomy. Under these circumstances it is important to measure lung function in these patients in order to gain a more complete understanding regarding early detection of pulmonary disease, and the evaluation of the therapy and management, particularly in survivors of laryngeal cancer. The aim of this study was to objectively assess the changes in pulmonary function parameters after tracheotomy and understand possible clinical applications for pulmonary function tests (PFT) in these patients.

Methods: 15 adult heavy smokers diagnosed with laryngeal cancer and managed by tracheotomy after surgical tumor resection were included in this research group. Preoperative basic pulmonary function datas (FVC, FEV_1, FEV_1/FVC, $FEF_{\%25-75}$, Peak Flow) were compared with postoperative datas measured on the first, fifth, and tenth day after tracheotomy. We also compared pulmonary function results before and after chest physical therapy in this group of patients.

Results: A highly significant ($p<0.001$) change in reduction of pulmonary function test parameters was found in postoperative data when compared with the preoperative date. In comparison of PFT results before and after chest physical therapy there were significant increases ($p<0.05$) in forced vital capacity (FVC), forced mid-expiratory flow rate ($FEF_{\%25-75}$), and a significant decrease ($p<0.05$) in $PaCO_2$ blood gas values, while the forced expiratory volume in one second (FEV_1), pereentage of the forced vital capacity (FEV_1/FVC), peak flow, and PaO2 blood gas values demonstrated no significant differences ($p>0.05$).

Conclusions: Our study findings suggest that the resection of the larynx possibly has an influence on these PFT parameters by decreasing the deadspace. Also, the differences in PFT results before and after chest physical therapy shows us that this therapy results in better PFT test results with these patients. Due to technical and standardization difficulties, and a lack of existing predicted pulmonary function test values for tracheostomized patients it is important to develop a different approach in the management of these patients.

OF-99-127

WEEKLY VS. DAILY CHANGES OF IN-LINE SUCTION CATHETERS: IMPACT ON RATES OF VENTILATOR-ASSOCIATED PNEUMONIA AND ASSOCIATED COSTS.

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Background: An earlier randomized controlled trial showed the changing from daily to weekly (or as-needed) changes of in-line suction catheters was associated with substantial cost savings without a higher rate of ventilator-associated pneumonia (VAP). To examine the impact of decreasing the frequency of changing in-line suction catheters in our MICU, we conducted an observational study comparing the catheter costs and frequency of VAP during two periods: 1. The control period, during which in-line suction catheters were changed daily, vs. 2. The treatment, during which the catheters were changed every 7 days or sooner for mechanical failure or soilage. **Methods:** All adult patients admitted to our eighteen-bed MICU were evaluated for 30 days proceeding the practice change (May 1999) and for 30 days thereafter. To avoid bias related variation in VAP frequency, we also examined the rates of VAP for the same 30-day period one-year earlier (May 1998). The occurrence of VAP was judged by an infection control nurse who standardly applied institutional criteria based on CDC guidelines. Rates of VAP were calculated as the mean/100 ventilator —days for each 30-day interval. Use of ventilators (Malinckrodt-Nellcor-Puritan-Bennett 7200 AE), humidifiers (Fisher & Paykel) and disposable non-heated wire circuits were uniform over the study. As were policies regarding humidity and temperature setting. **Result:** As a measure of the stability of VAP rates in the MICU, the frequency of VAP for the 30-day interval one year before the study was similar to the rate during the control period. During this control period, 36 patients accounted for 319 ventilator-days and no cases of VAP were observed. For the 30-day period after implementing the weekly catheter change policy, 42 patients accounted for 348 ventilator days and, as during the control period, no cases of VAP were observed. The mean (± SD) duration of in-line suction catheters used during the treatment period was 3.1 days ± 2.27 days and 43% of patients had the same catheter in place for > 3 days (range 4-9 days). The actual cost of catheters used during the treatment period was lower than during the control period ($355 vs. $2,201), predicted an annualized savings on catheter costs of $22,152. **Conclusions:** We conclude: (1) a policy of weekly vs. daily changes of in-line suction catheters was associated with substantial cost savings without any appreciable increase in the frequency of ventilator-associated pneumonia. (2) to the extent that these findings confirm the results of prior studies, they endorse a policy of changing in-line suction catheters weekly rather than daily.

OF-99-155

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THE ENDOTRACHEAL TUBE AIR LEAK TEST: IS IT A PREDICTOR OF POST-EXTUBATION STRIDOR?

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BACKGROUND: The endotracheal tube air leak test (ALT) is currently used in many PICUs to predict the success of extubation. We conducted a prospective study in two tertiary PICUs to evaluate whether the ALT is a predictor of post-extubation stridor or the need for reintubation.
METHODS: The ALT was performed by one investigator within 24 hours prior to extubation, as follows; 1) endotracheal tube was attached to an ambu-bag with pressure manometer and breathing gas circuit 2) stethoscope was placed over the larynx 3) pressure in the ambu-bag was slowly increased until air leak was auscultated 4) pressure on manometer was recorded 5) if no air leak was auscultated at 40 cm H_2O, the ALT was terminated. Cuffed tubes (n=4) were deflated prior to the ALT. Air leak was defined as presence of an auscultated air leak below 20 cm H_2O. Other data collected were duration of intubation, use of steroids prior to extubation, post-extubation stridor and reintubation. Statistical analysis used were t-Test and Chi-Square. Data are presented as mean ± SEM and $p<0.05$ was considered statistically significant.
RESULTS: A total of 34 patients were evaluated (27<4 yrs of age, 7≥4 yrs of age), 18 with air leak (AL) and 16 with no air leak (NAL). More patients in the NAL group had stridor (n=10) compared with the AL group (n=3, p=0.02). Evaluating all patients, the mean air leak pressure was higher (p=0.01) in patients with stridor (27.6±3.1) versus those without stridor (18.2±2.1). In the NAL group alone, the mean air leak pressure was not different in patients with (29.3±2.9) or without stridor (29.0±3.5). 16 patients received steroids, but no difference (p>0.05) was observed with the distribution of steroids used in groups (10/18 in AL, 6/16 in NAL). There was no association (p>0.05) between the use of steroids or the duration of intubation with stridor. All patients with stridor were treated with racemic epinephrine and one NAL patient failed extubation requiring reintubation.
CONCLUSION: The air leak test is a good predictor of post-extubation stridor. The likelihood of having post-extubation stridor is increased if there is no air leak below 20 cm H_2O (predictive value 62%). However, since extubation failure is rare despite post-extubation stridor, physicians must carefully examine the benefits of prolonging intubation while awaiting the air leak pressure to fall below 20 cm H_2O versus extubating patients and treating post-extubation stridor medically.

OF-99-188

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POST-ICU MECHANICAL VENTILATION: RESULTS OF A THERAPIST-IMPLEMENTED PATIENT SPECIFIC (TIPS©) WEANING PROTOCOL

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Background: Therapist driven protocols have been used to extubate or wean patients in the ICU setting. Barlow Respiratory Hospital (BRH), a 49-bed long-term acute care (LTAC) facility, has functioned as a center for weaning patients from prolonged mechanical ventilation (PMV). A therapist-implemented patient specific (TIPS) weaning protocol was developed at BRH to standardize weaning from PMV in the post-ICU setting. **Methods:** A weaning protocol incorporating the procedures and pace of LTAC weaning was developed using available scientific evidence, and expert consensus. After training of staff, data gathering, and analysis of pilot data, a major revision incorporated steps to accelerate weaning; the protocol was then implemented to include all ventilator-dependent patients. It was monitored for outcome, variance, and RCP and MD compliance. **Results:** 46 RCPs worked with four pulmonologists treating 103 consecutive patients admitted for weaning from PMV (a total of 4,115 ventilator days) over an eight month period. Eight patients were excluded from the protocol following initial evaluation. Of the remaining 95 patients, 93 have reached outcome. In the table below, results are compared to 238 patients treated by the same physicians in the two years prior to protocol weaning. The decrease in weaning duration was statistically significant for the TIPS patients vs. controls (p = .022). Outcomes, scored at discharge, are: W=weaned; V=ventilator-dependent; D=Died. Results are median values.

	n	Age	APS*	PVT**	Outcome - %			Weaning duration
					W	V	D	
TIPS	93	74	34.5	27 days	54	19	27	20 days
Control	238	71	33.5	30 days	58	11	31	29 days

*APS=APACHE III APS score; **PVT=Prior ventilator time (in ICU)

Physician compliance summary:

Steps not followed	45 episodes in 31 patients
Hold/resume orders	46 episodes in 29 patients (mean days held per episode = 5.2)
Hold/discharge orders	35 patients with modified goals or failure to wean

RCP compliance summary:

Steps not followed	39 episodes in 27 patients
Procedure not done	16 episodes (12 ABG, 3 RSBI, 1 telemetry)
Documentation omitted	6 episodes

Experience: A therapist implemented protocol for weaning patients from PMV was instituted and refined with a high degree of resultant physician and RCP compliance, with patient safety maintained. The protocol both organizes and objectifies the patients' weaning efforts, providing a valuable weaning history for treatment, utilization review, and discharge planning decisions. The expected benefit of enhanced interdisciplinary communication was also realized.

Conclusions: Weaning duration was significantly shorter using a protocol in this setting as compared to an historical control. Weaning outcome data during the period following implementation of the TIPS protocol are in fact attributable to the protocol's use.

OF-99-007

COST SAVINGS ASSOCIATED WITH IMPLEMENTATION OF A CHEST PHYSIOTHERAPY (CPT) PROTOCOL

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BACKGROUND: The use of Chest Physiotherapy (CPT), a component of bronchial hygiene therapy, has been demonstrated to be an effective therapeutic intervention in a number of disease entities. The patients that benefit from CPT have disease processes characterized by increased sputum volume, viscosity or ineffective mucocilliary clearance mechanisms. Conversely, the use of CPT has been shown to be of little or no benefit in diseases without these characteristics. Clinical deterioration of patients has been observed when CPT is used inappropriately. PROBLEM: After reviewing data regarding CPT utilization patterns within our institution, it was concluded a large number of ordered CPTs were inappropriate when compared with clinical indications from published studies and the AARCs CPG "Postural Drainage Therapy". Our management team and the Medical Director felt that development and implementation of a CPT protocol would reduce the number unnecessary CPTs being ordered. Our institution's CPT protocol was implemented in December of 1998. METHODS: We compared the data from the three busiest months of the year within our institution, December, January and February, for the year (97-98) prior to implementation of our CPT protocol with data for the same three month period (98-99) after CPT protocol implementation. The number of CPTs ordered in 96-97was compared to 97-98 data to ensure our "before" data wasn't an unusual variance. The volume of CPTs ordered 96-97 and 97-98 (pre-protocol data) were found to be comparable. Each CPT was assigned a 15" time value and cost included salaries and benefits. RESULTS:

	CPT Procedures	Cost of Service	% Reduction	Cost Savings
Pre-Protocol (Dec-Jan-Feb 97-98)	20,647	$106,848.23		
Post- Protocol (Dec-Jan-Feb 98-99)	9,567	$49,509.23		
Cost Savings				$57,339.00
% Reduction (CPTs Procedures)			53.7%	

Prior to the CPT protocol implementation 9.92 FTEs were required to provide this service while after protocol implementation 4.60 FTEs were required. This resulted in the equivalent of 5.32 FTEs that could be redirected to more appropriate clinical activities. Outcome data is currently being collected to ensure appropriate patient selection for CPT. EXPERIENCE: The authors have 31 years of combined experience in Respiratory Care with each participating in previous protocol development. CONCLUSION: Implementation of a CPT protocol, with appropriate medical and administrative support, can result in significant cost savings and can allow redirection of valuable FTEs to more appropriate clinical activities.

OF-99-010

THE IMPACT OF FAST TRAC WEANING & COST CONTAINMENT IN THE ACUTE CARE SETTING

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INTRODUCTION: Managed-care continuously challenges all departments to revise and reassess the methods and equipment utilized to deliver optimum patient care. Fast Trac Weaning helped us meet the challenge. Fast Trac Weaning is defined, by the Journal of Anesthesiology, as extubation within 1 to 6 hours after cardiac surgery.

Fast Trac Weaning and a dedicated program to monitor supply - equipment cost and man-hours has proven to have positive outcomes. The greatest benefit was experienced by our patients. Specifically, they experienced less anxiety due to the shorter length of intubation. Adopting Fast Trac Weaning has also decreased length of stay, patient and hospital cost, and increased staff productivity.

METHODS: We identified the need for the same ventilator tubing to follow the patient through their continuum of care. A protocol was developed that outlined single use circuitry. This standard of practice eliminated multiple tubing changes at point of transport and extubation. By utilizing the surgical patient's current ventilator circuit in multiple settings, we eliminated the set up of additional tubing on transfer and at post-extubation.

The criteria selected to evaluate the effectiveness of this method consisted of: the incidence of inadvertent extubations; the incidence of elective reintubation post-Fast Trac Weaning; equipment cost comparison; personnel productivity; and patient length of stay.

CONCLUSION: Comparing airway management standard of practice with innovative equipment options and/or modifications resulted in several benefits. This change in practice using single circuitry in a triple function role resulted in increased patient satisfaction, decreased patient length of stay, decreased cost in equipment and labor, and increased staff productivity. Specifically, $11,640.00 per 1,000 patients in disposable equipment alone.

The utilization of the Fast Trac Weaning protocol also resulted in decreased inadvertent extubations, decreased elective reintubations and decreased adverse reactions. Fast Trac Weaning has been proven to be a safe and preferred method that has impacted significant cost containment in our acute post-operative care setting.

OF-99-016

STAFF PERCEPTIONS OF CROSS-TRAINING TO MEET DEPARTMENT COST CONTAINMENT PROGRAMS.

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INTRODUCTION. Health care reform has dictated significant changes in operations of health centers. Respiratory Care departments have struggled to meet these financial demands through downsizing and institutional realignments while providing optimum patient care. One approach to meet the department goals of patient care in face of decreased funding is to utilization work redesign models involving cross-training of employees. UMHHS is a large tertiary teaching institution which has recently implemented a significant cost-containment program. Respiratory Care, at UMHHS, has historically operated as two distinct departments; adult and pediatric/neonatal. Each department has being solely responsible for the staffing and financial operations within each patient population. To comply with the institutional cost containment goals, Respiratory Care services where integrated into one operation and staff were required to provide service support between pediatrics and adults. We examined our ability to meet operational goals and staff perceptions following the implementation of this cross-training effort. **METHODS.** Staffing positions, financial cost and services were obtained over the past four fiscal years from department records and hospital finance reports. A survey was constructed and distributed to staff members who have been actively involved with the cross-training program, as well as, staff members who did not participate. The purpose of the survey was to identify staff perceptions and concerns about cross-training. **RESULTS.** Over the past 4 fiscal years, total staff FTE's have decreased 19.9 positions (17.1%). Service support (billable procedures or activity hours) have demonstrated stable or slight increase over the same time period. Cross-train support hours, however, have increased 93% (FY96 versus FY98). 70% of the adult therapists who responded to our employee survey, felt that the cross-training program helped to reduce overtime and on-call support. In contrast, only 5% of the pediatric therapists who responded felt that cross-training helped to reduce overtime and on-call. 35% of the adult staff and 37% of the pediatric staff felt that the quality of care provided by cross-trained therapist maintained departmental standards. **CONCLUSIONS.** Our results indicate that expanding job responsibilities for staff therapists help to meet the financial objectives for the department and institution. However, the staff perceptions significantly contrast with institutional objectives. A significant number of staff involved, either directly or indirectly, with this type of work redesign do not perceive benefits associated with cross-training service support. These perceptions must be addressed to meet the increasing demands placed upon RC departments as we proceed with health care reform.

OF-99-030

CAN MODIFIED ACADEMIC DETAILING IMPROVE HOMEGOING MEDICATION PRESCRIBING FOR HOSPITALIZED ASTHMATICS?

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History: Hospital admission for acute asthma constitutes a major treatment failure. Although there are multiple causes for severe asthma exacerbations, prescribing inadequate medications based on level of chronic disease severity may be a significant contributing factor. The revised asthma guidelines published by the NAEPP/NIH in 1997 stressed the importance in prescribing medications based on disease severity. **Aim:** Determine if asthma patients' medications are appropriate for chronic disease severity on admission to our pediatric hospital, and employ a modified academic detailing model to improve discharge prescriptions. **Methods:** As part of our asthma disease management program, we obtain a standardized admission history that includes information on patients' recent symptoms, prescribed medications, daily activity impairment and health care utilization. From this data, we are able to determine a chronic asthma severity class based on NIH guidelines. All patients are evaluated as mild intermittent (MI), mild persistent (MIP), moderate persistent (MOP), severe persistent (SP), and severe life threatening (SLT). A pediatric pulmonologist suggests homegoing medications for each patient based on this disease severity data. Shortly after hospital admission, these severity-based recommendations are placed in each patient's chart for their primary care physicians (PCP) or facility-based attending. We compared chronic medications at admission vs. those prescribed at discharge. **Results:** Complete data was reviewed for 241 patients. Breakdown by severity class: MI = 47, MIP = 86, MOP = 75, Sp = 29, SLT = 4. On admission, 74% of patients had inappropriate chronic medications by disease severity according to NIH/NAEPP guidelines. Underprescribing increased with disease severity (MI-45%, MIP-72%, MOP-85%, SP-97%, SLT-100%). With this intervention available to PCPs prior to discharge, 82% of the patients had medication upgrades to match severity. The lowest increase was found in patients with MOP (72%). All severity classes had significant (p<.05) upgrades in medications at discharge. Albuterol as the only routine medication prescribed decreased from 53.9% to 17.4%. Prescribing cromolyn and/or inhaled steroids increased in both MIP (29% - 85%) & MOP (71% - 95%) severity classes.

Table 1. Medications by Severity Class on Admission (%)

	Alb, Only	Alb/Intal	Alb/ICS	Alb/Intal/ICS	Alb/ICS/other
MI	95.7	4.3	0	0	0
MIP	69.8	26.7	2.3	1.2	0
MOP	28	56	12	4	0
SP	13.8	62.1	17.2	6.9	0
SLT	0	75	0	0	25

Table 2. Medications by Severity Class at Discharge (%)

	Alb, Only	Alb/Intal	Alb/ICS	Alb/Intal/ICS	Alb/ICS/other	p value
MI	57.4	36.2	0	6.4	0	<0.001
MIP	14	62.8	16.3	5.8	1.1	<0.001
MOP	4	48	32	6.7	9.7	<0.001
SP	0	17.2	51.7	3.4	28.4	<0.001
SLT	0	0	0	0	4	<0.029

Conclusions: A modified academic detailing model can improve chronic medication regimens of pediatric asthmatics that are hospitalized. Further long-term follow-up studies are indicated.

OF-99-044

OUTCOMES BASED CLINICAL RESEARCH UTILIZING RESPIRATORY CARE PRACTIONERS.

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Background: Clinical research depends on reliable follow-through in every aspect of the project. A system must be in place to identify all potential study patients, to successfully enroll and follow eligible subjects, and to characterize those lost in the enrollment and follow-up process. A large, nationally funded study at our institution piloted the use of hospital-based Respiratory Care Practitioners (RCP) to execute these aspects of an outcomes-based research project. The project manager, as well as telephone, in-patient and home care follow-up, and data abstraction and entry personnel were recruited from the Respiratory Care Department. **Methods:** A prospective cohort study of children age 2 years and older treated in an ED for acute asthma exacerbation was undertaken. The goal of the study was to identify, at the time of ED visit, significant historical and clinical patient characteristics for the development of a prediction model of ED disposition. ED RCP's were involved in subject identification, patient enrollment, clinical assessment and treatment during the acute exacerbation, and in inpatient and outpatient follow-up. Three main outcomes were measured: need for hospital admission, clinical severity, and functional status. Clinical severity was measured on all asthma patients with a validated scoring system. Both functional assessment and clinical severity were measured at the time of ED visit, 24 hours (as in-patient, telephone interview or home visit) and two weeks after discharge. Interrater reliability indicated substantial interobserver agreement among RCP's and ED physicians.[1] **Results:** 679 patients have been enrolled to date. 98% of all eligible patients were identified and approached by the ED RCP, 7% refused, 91% were successfully enrolled. Twenty-five percent of enrolled patients were admitted and followed-up as in-patients. Five percent of patients discharged from ED received a home visit at 24 hours. The remainder of enrolled patients had follow-up at 24 hours by telephone interview. All patients were contacted by telephone for two-week follow-up. Enrollment, clinical assessment and treatment by RCP's was part of routine patient care. Outpatient follow-up and data management (abstraction and data base entry) was completed by RCP's hired by the study on an hourly basis.

Percent eligible enrolled	91%
Successful telephone follow-up	93%
Successful in-patient follow-up	96%

Conclusions: Our experience has proven that the utilization of hospital-based Respiratory Care Practitioners in a large, nationally funded outcomes-based research project can provide excellent enrollment, assessment, follow-up and data management.

[1] Stevens, Gorelick, Schultz. Interrater Agreement in the Evaluation of Pediatric Asthma Severity. Academic Emergency Medicine. May 1999 (abstract)

OF-99-055

PEDIATRIC INTENSIVE CARE RESOURCE ALLOCATION: A TEAM MODEL

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Background: In an attempt to evaluate the allocation of nursing and respiratory care resources in our Pediatric Intensive Care Unit (PICU), a group of nurses (RN) and respiratory therapists (RRT) were assembled. Physician input was also solicited. The goal of the project was to determine if redundancies could be eliminated and efficiency improved by the reallocation of resources. If this goal could be met then an improvement in the quality of care would be the natural result. **Methods:** The group evaluated all patient care activities and procedures performed in the PICU. The activities/procedures were placed in a table and divided to indicate which should only be performed by an RN or an RRT. This was performed according to the scope of practice for each discipline. The remaining activities/procedures were ascribed to either discipline. The group endeavored to maintain discipline specific identity and responsibilities. The approach taken was to view participants as members of a patient care team, with no one group in charge of the other. A pilot group of staff, from both disciplines, were then recruited to participate. An extensive multi-disciplinary educational process was begun. An emphasis was placed on teamwork during this training, with each participant spending clinical time with another participant from the other discipline. Competency assessment evaluation occurred for all cross-trained activities. A multi-disciplinary patient care flow sheet was concurrently developed. This would allow either group to document patient assessment and interventions in the same manner. For the pilot, one RRT (beyond the PICU normal staffing) was assigned to participate 24 hours a day from Monday to Friday for a six week period. The RRT was matched with one or two RNs and provided care to the patients assigned to the team. The ratio of RN to RRT varied according to acuity level of the patient(s), as ranked by the charge RN for the shift. The average ratio was two RNs to one RRT with two to four patients assigned to the team. There were several occasions when patients with very high acuity scores were assigned one RN/one RRT. We realized that justifying the benefits of this model would be difficult. A survey tool was developed to ascertain as much objective input as possible. Physicians, nurses and therapists, all having worked in our traditional model and the team model, completed these surveys. The outcomes surveyed were: communication between health care workers, timeliness of care, and availability of personnel along with response time. The areas were rated on a scale of 0 to 5, with 5 being best, 3 the same and 0 worst. **Results:** The findings were as follows:

Communication between health care workers	5
Timeliness of care	4.5
Availability of personnel/response time	4.5

The team felt that patients received a better quality of care secondary to improvements in communication, timeliness and availability of resources. **Conclusions:** Despite apprehension from both groups at the start of the pilot, participants totally supported it at completion. The desire and effort to maintain discipline specific identity and responsibilities dispelled the fears encountered in many redesign efforts. The future goal is to use this model and incorporate the RRT hours necessary to provide care into the PICU budget, while still maintaining a centralized respiratory care department structure. Preliminary data suggest implementation of this model will result in a modification of how resources are allocated to the PICU.

OF-99-052

IS LAUGHTER THE BEST MEDICINE?

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Question? Does a sense of humor help patients cope with stressful events in their lives? Can humor & laughter stimulate changes in the body that enhance health & facilitate recovery from illness? Facts: Excessive, unrelenting stress can lead to illness. Stress can weaken the immune system and predispose one to infection. Humor & laughter can mitigate the effects of stress and aid in the recovery from illness. Hypothesis: Humor will modify emotional response to stress. Humor will stimulate the immune system. Methods & Results: In a carefully controlled study, the immune response of a group of pneumonia patients of similar age was examined. These patients were visited for 1 hour x 3 days by HaHaS, (Health & Healing at Southwest) Caring Clowns. This troop of merry-makers are Respiratory Therapists specially trained in therapeutic humor. The patients were entertained by costumed clown antics, puppetry, jokes, and funny videos. Blood pressure, heart rate, and blood samples were analyzed before during and after the comedy routines. A similar control group that did not experience the humorous intervention was used for comparison. One finding revealed that serum cortisol levels *decreased significantly* in the group experiencing the laughter. Cortisol levels are known to *increase* during the experience of stressful emotions, when the brain signals the adrenal gland to produce corticosteroids, which will increase blood sugar and decrease the immune response. Blood pressure *decreased* an avg. of 20% and heart rate also *decreased* an avg. of 20 bpm in the group that received therapeutic humor. Conclusion: These findings support the hypothesis that laughter keeps our immune system strong. The data also suggests that laughter can trigger physiological changes such as improved circulation and release of endorphins that make the patients feel less pain. Although these are measurable effects, it does not mean that telling jokes or watching comedies actually help cure illness. No one can make that claim. What *is* apparent is laughter produces these effects in the body and contributes, to some extent, to mental and physical well being.

OF-99-059

THE FINANCIAL EFFECT OF A CHRONIC VENTILATOR/ RESPIRATORY CARE UNIT IN AN ACUTE CARE HOSPITAL: A SIX YEAR EXPERIENCE.

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Very little has been reported in the medical literature regarding the financial effect of caring for stable ventilator dependent patients and other patients needing intensive respiratory in a special unit other than an intensive care unit (ICU). At our institution, St.Mary's Hospital/Mayo Medical Center, a special unit was opened on January 1, 1990, to house chronic ventilator dependent patients (CVDU). The purpose of the unit was to either wean the patient from the ventilator or train the patient and the caregivers to provide home airway and ventilator care. In 1994 the size and mission of this unit was expanded to permit the care of non-invasive ventilator patients and tracheostomy patients requiring consistent and adequate airway management outside of an ICU. During the period January 1, 1993 through December 31, 1998, 964 patients were admitted to this unit for 12,075 patient days of care. Of the total, 420 were ventilator dependent with tracheostomies, 339 were admitted for establishment of and training in non-invasive ventilation or for intensive airway/tracheostomy and respiratory care. 49% of the patients were admitted from four major surgical ICU's (thoracic and vascular surgery, emergency room/trauma/general surgery, cardiovascular surgery and neurosurgery). The remainder of the patients were transferred from the medical ICU and the coronary care unit. Another 205 patients on home ventilators and/or with chronic tracheostomies, were admitted directly to the CVDU.

We carried out a cost analysis of the various ICU's, that transferred patients to the CVDU by year from 1993 through 1998. In addition costs for the CVDU were established by year for the same period. Both direct and indirect costs were identified. We then calculated the cost effect of transferring these patients for care from high cost ICU's to the lower cost CVDU. The cost savings for the six years was calculated for each ICU transferring patients to the CVDU. During the six years of this study $4,832,551 in patient care costs were saved by moving patients from ICU's to the CVDU ($3,183,029 in savings was realized in invasively ventilated patients and $1,005,574 in the care of non-invasive ventilator patients and tracheostomy patients requiring consistent and adequate airway management outside of an ICU). The cost savings on 205 patients directly admitted was $643,948. In addition, the rate of successful liberation from the ventilator and survival was calculated for all ventilator dependent patients. These data will be presented in details

OF-99-063

RESPIRATORY CARE PRACTITIONER AWARENESS OF POTENTIALLY HARMFUL VENTILATOR SETTINGS CAN IMPROVE CLINICAL OUTCOME

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INTRODUCTION/HYPOTHESIS: Respiratory Care Service at our institution provides approximately 40,000 hours of mechanical ventilation per month to adult patients. We were concerned that clinical practice was inconsistent and practitioner awareness of potentially harmful ventilator settings was lacking. We hypothesized that by identifying potentially harmful ventilator settings and subsequently educating practitioners, we could improve clinical outcome and consistency in the management of mechanically ventilated patients. EVALUATION METHOD: Five undesirable ventilator parameters were identified: FIO2 > 0.60, Plateau pressures > 35 cm H2O, Presence of auto-PEEP, Patient-ventilator dyssynchrony, and lack of weaning when weaning criteria is met. Initial data was collected on 159 mechanically ventilated patients and revealed that 55 (35%) had at least one undesirable parameter present. INTERVENTION: Training was conducted for all intensive care practitioners. Course curriculum included target settings, modes of ventilation, considerations for weaning (stable hemodynamcis with systolic BP > 90 and Dopamine < 5 mcg/kg/min; stable hemoglobin with PaO2 > than 60 on 40% O2; spontaneous respiratory rate < 30 bpm and no neuromuscular blockers) and ventilator graphics. Practitioners attended four-hour workshops and were required to pass a written exam inclusive of graphic interpretation and case studies. The department information system was also configured to mandate documentation of the five undesirable parameters with each ventilator monitoring round. The desired target was 90% of all ventilator settings to be within optimal range, and that 95% of patients meeting weaning criteria were actively being weaned. RESULTS: Monthly averages of undesirable ventilator parameters from August 1998 and March 1999 (total of 4692 parameter entries) illustrate substantial performance improvement after the intervention:

Month	%FIO2<.60	%Plat Press<35	%No autoPEEP	%No Dysn.	%Appr. wean
8/98	84.2	89.9	94.5	92.9	100
3/99	93.2	96.3	97.3	94.9	100

By identifying potentially harmful settings, providing practitioner training and requiring continued monitors, clinical outcome and consistency has improved with mechanically ventilated patients.

OF-99-078

EVALUATION OF A THERAPIST-DIRECTED ASTHMA MANAGEMENT PROGRAM AND ITS IMPACT ON RESOURCE UTILIZATION

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A therapist-directed outpatient asthma management program was instituted at our facility in Nov.1997. The foundation of this program is grounded in recommendations from NAEPP's Expert Panel Report II published that same year. The program goals included 1) enhancement of patient self-management through education and follow-up, 2) decreased Emergency Room (ER) and hospital utilization, and 3) complement/supplement to physician management of asthma. Key components of the program include: easy access upon physician referral, one-on-one assessment and education, individual care plan development, intensive and ongoing monitoring which includes outpatient visits and telephone follow-up, and medication management following NIH guidelines. The **Purpose** of this study was to determine the effectiveness of this program on frequency of ER visits and hospitalizations for acute exacerbations of asthma. **Methods:** Between Nov. 97 and August 1998, 67 patients were referred to the program. Patient profiles identified: 84% of patients were female, 52% Caucasian, 42% African-American and 6% other. Ninety percent of the patients were over 17 years of age. Patient's asthma status was rated on admission based upon the NIH classification system. Eighty percent were admitted with moderate persistent (Step 3) or severe persistent (Step 4) asthma. Eight patients received education only (no follow-up) and nine were dropped due to non-compliance (85% compliance). Patients included in the study were active in the program for a minimum of 8 weeks and had outcome data available and monitored for a minimum of 6 months. Fifty patients met these criteria. These fifty patients served as their own controls in a "mirrored" evaluation from the point of referral into the Asthma Management Program. This allowed for comparison of ER and hospitalization rates at our institution for similar periods of time for each patient, before and after starting the program. Statistical analysis was done using paired t-test. **Results:** When comparing pre-program to post-program values at greater than 95% confidence levels, positive outcomes are demonstrated.

n = 50	ER Visits X (SD)	Hospitalizations X (SD)
Pre-Program	1.54 (2.99)	0.40 (0.57)
Post-Program	0.22 (0.58)	0.12 (0.39)
p =	0.002	0.005

Conclusions: In our program, the benefits of individualized education, self-monitoring, aggressive supervision and medication management have all contributed to significant reductions in ER visits as well as hospital admissions at our facility. These improved outcomes demonstrate that a Therapist-Directed asthma management program can be effective in assisting asthmatic patients in their self-management initiatives.

OF-99-064

TREATMENT TIMES STANDARDS FOR CHEST PHYSIOTHERAPY

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Background: Managing productivity is based on establishing time standards associated with the provision of treatment. UCSD has incorporated several alternative techniques to facilitate secretion clearance that include Flutter Valve, Intrapulmonary Percussion, and ThAIRapy Vest. Expert opinion was initially utilized to determine the duration of these procedures, as they were not included in the AARC Uniform Reporting Manual. To validate the actual time associated with the provision of these therapies, we utilized our point of care information system to capture and determine treatment duration for managing productivity. **Methods:** The department information system was configured to include the procedures of Limited Chest PT, Comprehensive Chest PT, and the new alternative therapies. Treatments were then provided per department secretion clearance protocol in which the method of chest physiotherapy was determined. The duration of each treatment was captured by entry of start and stop times directly into the mobile workstation. Information was collected over a four-month period and data was analyzed to determine measures of central tendency. **Results:** Duration times are reported in minutes for both mean and mode.

Procedure Name	# of Treatments	Mean	Mode
Limited Chest PT	2756	18.15	15
Comprehensive Chest PT	30	32.12	30
Flutter Valve	50	13.66	15
Intrapulmonary Percussion	181	18.79	15
ThAIRapy Vest	377	24.87	30

Discussion: There is significant variance in the time duration for the alternative methods of secretion clearance. Determination and refinement of time standards provides a means to assess staffing requirements based on the number and mix of these procedures. In addition, time standards will facilitate the determination of labor cost and the transition to less costly interventions when such therapy is effective in achieving the desired outcomes.

OF-99-087

EXTENDED EXPERIENCE WITH A RESPIRATORY SPECIAL CARE UNIT (ReSCU) AT THE CLEVELAND CLINIC FOUNDATION. James K. Stoller, MD, Richard D. Rice, BS RRT, The Cleveland Clinic Foundation, Cleveland, Ohio
BACKGROUND: We previously reported (Am J Respir Crit Care Med 1998;157:A18) hospital outcomes of the first 212 patients managed in the Respiratory Special Care Unit between its inception (August 22, 1993) and August 13, 1997. To assess whether clinical outcomes have remained consistent over time thereafter, we assessed our experience with an additional 101 ReSCU patients admitted between August 14, 1997 and April 5, 1999. **METHODS:** Features of the ReSCU include 6 private beds on the pulmonary specialty ward staffed by nurses with special pulmonary and rehabilitation expertise, 24 hour respiratory therapy supervision, non-invasive monitoring (continuous pulse oximetry, end tidal capnometry, and ventilator alarms) with signal output at each bedside and at a central monitoring station, a multidisciplinary approach involving dieticians, physical therapists, and speech pathologists. Eligibility criteria have been consistent since the ReSCU opening and include hemodynamic stability, absence of an arrhythmia requiring telemetry, and, in the attending physicians' judgement, the ability to benefit from the ReSCU. Admission priority was given to patients who are deemed weanable, with all patients referred to the ReSCU from intensive care units in our institution. **RESULTS:** Between August 14, 1997 (when the prior series closed) and April 5, 1999, 101 additional ReSCU patients have accounted for 114 total ReSCU admissions. Of these 101 patients, 89 were admitted to the ReSCU once, 11 twice, and 1 three times. As in the prior series, most current patients were female (54% vs. 55%). The mean (± SD) age of current patients was 66 (± 13) years. Overall, recent outcomes are similar to those in the first 49 months of ReSCU operation. Specifically, compared to prior experience, the rate of hospital survival in the current series was 80% (vs. 82% in the prior series). Among the 81 current survivors, 55% achieved complete ventilator independence (vs. 60% previously), 20% required complete ventilator dependence (vs. 13%), and 7% required partial ventilatory support (vs. 9%). The mean (± SD) length of ReSCU stay for these 101 patients was 16 days (± 13) vs. 23 days (± 21) previously. Finally, ReSCU days accounted for 38% of the total hospital length of stay. **CONCLUSIONS:** 1.Clinical outcomes in a cohort of ReSCU patients admitted since August 14, 1997 are similar to those previously described for the first 49 months of ReSCU operation. These outcomes indicate a high rate of hospital survival and, among survivors, a high rate of achieving ventilator independence. 2. These outcomes were preserved with a shorter mean length of ReSCU stay than before. 3. Attainment and maintenance of these outcomes likely reflects a consistent application of selection criteria by a stable group of attending physicians, and consistent patterns of care by a stable group of nurses, respiratory therapists, and other allied health providers.

OF-99-111

A System of Universal Peer Evaluation

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Introduction:. Peers are often in a better position to evaluate peer job performance than are supervisors. The Central Limit Theorem implies that the more measurements we take, the more likely it is that the sample mean will equal the true mean. We have instituted a system of computer based peer evaluations. A committee of staff and management developed evaluation criteria and assigned weights to each criterion based upon departmental goals. If restructuring is ongoing, a higher weight may be given "Adapts to rapid changes easily". If absenteeism is a problem, it might be assigned 7% of the overall evaluation. Staff members prepare a statement factors they wish taken into account by their evaluators. This is distributed to the latter. A spreadsheet template is copied to a floppy disk or network. The spreadsheet consists of evaluation criteria in the A column, percent weight in B and names in column C. The screen is split and frozen keeping names in the first row and evaluation criteria in the first column. Staff members are taught to 1) open the spreadsheet 2) enter the evaluation data and 3) save the spreadsheet with an access code. Very high or low scores requires a justifying comment. Management later produces a hard copy for review and signature. A person in management is given the disk or accesses the spreadsheet. A macro copies the scores for each therapist to an individual's array in a master spreadsheet, criteria in rows and evaluators columns. All scores are averaged and the standard deviation computed. The array is copied again by a conditional statement which blanks out all individual scores which are more than two standard deviations from the mean. Those scores are multiplied by assigned weight to produce a total score. Management edits the comments and individual therapists are given the average score in each category, comments and the overall score. Scores determine merit increases. Anyone who rates "Unsatisfactory" is not allowed to evaluate others the following year. Peer evaluations resulted in major behavioral changes with a 17% improvement in overall scores between year 1 and year 2. There were fewer complaints about favoritism. Peers were more critical of peers than was management. Confidentiality became an issue as some tried to find out the sources of low scores.

OF-99-117

OUTCOME IMPROVEMENT FOR THE MECHANICALLY VENTILATED PATIENT. Chaitanyan Acharya, MD; Gordon Turner, MD; Homer Engert, RRT; Laurie Tamminga, RRT; Laura Van Heest, RRT; Jane Visser, RN. Saint Mary's Mercy Medical Center, Grand Rapids, MI.

BACKGROUND: Ventilator length of stay (LOS) was selected to evaluate the quality of treatment in the critical care unit of a 330-bed teaching hospital. A LOS retrospective review in 1997 included all patients in a 14-bed mixed medical/surgical critical care unit and all patients in an intermediate unit. The critical care teams was mandated to reduce ventilator LOS by 30% after the review found the average LOS in 1997 to be 9.25 days

METHOD: The multi-disciplinary team devised a process of improvement using the Institute for Health Care Improvement Rapid Cycle method and PDCA. The team revised the multiple physician-driven wean strategies process, wrote and implemented strategies and protocols for Pressure Support Wean and Oxygen Titration to 50%. Early in the process, daily team meetings were instituted to review each patient's status and empower respiratory therapists to implement protocols and procedures.

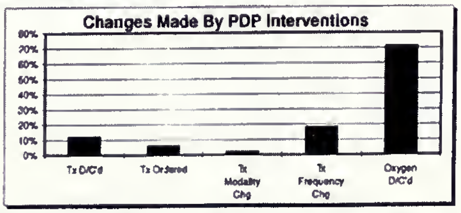
RESULTS: By the end of year one, ventilator LOS was reduced by 39% to 5.6 days. Oxygen titration to 50% or less became practice in 97% of all appropriate cases and nosocomial pneumonia was reduced from 17.3% to 13.7%. All improvements have been sustained to date. Severity adjusted mortality and acuity was unchanged.

EXPERIENCE: Prior to the formation of the multi-disciplinary team, respiratory therapists (including LT & LVH) were not involved in patient care planning. The increase in autonomy for respiratory therapists' involvement in the care and planning of care and their contribution to problems solving has been recognized as a significant factor in the success of this process improvement.

CONCLUSION: Positive outcomes are attributed to teamwork, decrease in variation of practice, and emphasis on respiratory therapists' management of ventilated patients. JCAHO surveyors scored Saint Mary's "98". At the summary conference they cited the successful achievement of the team's objective. The team next plans to implement Lung Protection Strategies and access to new technology, such as APRV (bi-level), and Esophageal Doppler monitoring, as further improvements for mechanically ventilated patients.

OF-99-115

PATIENT DRIVEN PROTOCOLS -- A NINE MONTH PROSPECTIVE STUDY
Rikki Bruinsma, RRT/CPFT, Charles D. Burger, MD, Wayne L. Downey, RRT, James J. Reagan, Jr., RRT. St. Luke's Hospital, Jacksonville, FL.
Background: A study of the Patient Driven Protocol (PDP) and Respiratory Consult Service (RCS) was performed to determine its effectiveness in ensuring the delivery of appropriate therapy as defined by the AARC Clinical Practice Guidelines. PDPs were developed in 1995 and 1996 for the following modalities: Medicated Aerosol Therapy, Volume Expansion, and Chest Physiotherapy. Within 24 hours of the initiation of physician ordered therapy, a PDP Evaluator assesses the patient, using a symptom-based scoring tool, for appropriateness of therapy. Therapy may be continued as originally ordered or changed based on the PDP Evaluator's assessment. The RCS, implemented 12/97, gives physicians an option of directly consulting with a Respiratory Care Practitioner (RCP) regarding a patient's need for therapy. All therapy is re-evaluated at least every 72 hours for appropriateness. The oxygen protocol, developed in 1995, enables RCPs to titrate supplemental O_2 usage to maintain a patient's $SpO_2 \geq 92\%$. **Method:** The number of treatments discontinued, initiated and/or changed (frequency or modality) was recorded from 1/98 through 9/98. Data was also collected regarding the total number of inpatients with respiratory-related orders. **Results:** There were a total of 1,654 initial and 1,893 re-evaluations performed on 2,896 ordered therapies. The total number of patients qualified for the O_2 protocol was 2,227. The PDP interventions resulted in a significant number of treatments (38%) and oxygen (71%) to be either changed or discontinued.


Changes Made By PDP Interventions

Experience: Since the inception of PDPs and the RCS, the delivery of inappropriate therapy has decreased while physician approval of the protocols and requests for RCs have increased.
Conclusion: The number of changes made in treatments and oxygen therapy, in addition to feedback received from physicians, suggest PDPs have been successful in ensuring the appropriate delivery of respiratory therapy. A reduction in FTEs in Respiratory Services has not been realized; however, the decrease in the delivery of unnecessary therapy may have reduced cost by decreasing equipment, medication and oxygen usage. Additionally, because treatments are given to those patients who actually require them, the quality of patient care seems enhanced.

OF-99-126

EVALUATION OF THE PROCESS AND TIMING OF ORDERING AND PROVIDING RESPIRATORY CARE SERVICES.

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BACKGROUND: To establish a baseline pattern for assessing the impact of a radio frequencyñdirected management information system, we evaluated the current process and timing by which consult-based respiratory care services are ordered and delivered on inpatient wards at The Cleveland Clinic Foundation 1,000 bed teaching hospital.. Presently, the sequence by which orders are placed and administered is as follows: 1. a ward secretary transfers a written order to a computer entry system, and 2. The entry system interfaces with a respiratory care management information system (CliniVision, Nellcor Puritan-Bennett), which notifies Respiratory Care of the new orders. New orders are then incorporated into the therapists' workload during the mid-shift hand-held computer upload. When assignment are made for the next shift, each therapist is called for an update on the number of treatments added or discontinued from their workload. At the end of the shift, the current shift therapists walk to the Respiratory Care department in order to upload new patient information important to the next shift therapists' care. This information is then downloaded to the next shift therapists' hand-held computers. **METHODS:** Using our CliniVision database, we evaluated 95 patients covered by a therapist exclusively assigned to cover one nursing ward (G81) and 100 patients covered by a therapist assigned to (4 other wards (H51). The ordering process and timing of respiratory care was evaluated by several outcome measures: 1. The time elapsed between receipt of the order and initiation of respiratory therapy, 2. the number of patients for whom respiratory therapy orders were initiated prior to transfer of the written order to CliniVision, 3. the time required for all activities related to making work assignments for the following shift, and 4. the time interval between the end of the shift report and preparation of the hand-held computers for distribution to individual therapists. All measurements were based on the mean values for 3 assignment periods.

Initiation of Therapy	**G 81**	**H 51**
Number of patients studied	95	100
Average time (hours) from notification to initiation of treatment	3.8	8.02
Number of patients started on therapy prior to notification	28 (29%)	7 (7%)
Number of patients who waited > 8 hours for therapy	6 (6%)	32 (32%)
New Shift Assignments	**Total For All Wards**	
Time to prepare next shift assignments (minutes)	35.4	
Total time waiting for and up-loading all hand-helds (minutes)	28.3	

RESULTS: The following table shows these mean values:
CONCLUSIONS:

1. With the current system using hand-held computers, a substantial amount of time is spent preparing shift assignments and uploading the hand-held computers in order to assign workloads.
2. The time between notifying the therapist and initiating orders was less for a therapist assigned to a single ward than for a therapist assigned to multiple wards.
3. These data provide a baseline against which similar measurements using a radio-frequency system for information management should allow useful comparison for assessing the benefits of this new technology.

OF-99-128

EVALUATION OF A THERAPIST-DIRECTED PROTOCOL FOR THE MANAGEMENT OF ASTHMA IN THE EMERGENCY DEPARTMENT.

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Gary Weinstein, MD and Semra Aytur, MPH. Presbyterian Hospital of Dallas, Dallas, Texas.

A therapist-directed protocol was instituted for managing patients presenting to the Emergency Department (ED) with asthma symptoms. The protocol uses a severity classification scoring system to drive the treatment plan. Both the scoring system and treatment plan are based upon the NAEPP's Expert Panel Report 2 published in 1997. The **Purpose** of this study was to determine: 1) the effect of this protocol on patient treatment time, 2) the usefulness of the severity index as a predictor of hospital admissions and 3) the effect of using higher dose beta-agonists (≥1.0cc of albuterol 5mg/mL) on hospital admission rates. **Methods:** We retrospectively reviewed 972 consecutive ED visits in which the protocol was initiated and a severity assessment was performed. The scoring index stratified patients into Mild (n=394), Moderate (n=543) or Severe (n=35) categories. Each category specified a course of treatment which may have included, inhaled beta-agonists and anticholinergics, supplemental oxygen and systemic steroids. Upon conclusion of the treatment plan, a decision was made as to patient disposition (home or admit). Statistical analysis was performed using nonparametric correlation and logistic regression. **Results:** Indicated 1) a significant correlation between the patient's initial severity level and the total amount of time the patient received treatment, with higher severity patients receiving more time (Spearman correlation coefficient .200, $p <0.001$). 2) patients with a Moderate or Severe initial severity score were more likely to be admitted to the hospital relative to Mild patients, even when controlling for age (Moderate OR 2.7, $p<0.0001$; Severe OR 14.2, $p<0.0001$). 3) higher beta-agonist dosage had no statistically significant effect on hospital admission rates ($p>0.05$). **Conclusions:** A therapist directed protocol for managing asthma exacerbations in the ED proved to be useful in matching the intensity of services to patient acuity. The severity composite scoring index was shown to be a significant independent predictor of hospital admission with moderate patients almost 3 times more likely to be admitted and severe patients being 14 times more likely to be admitted. Administering higher dose beta-agonists did not show a significant effect in decreasing hospital admissions. This was most likely due to confounding by severity level (more severe patients receiving higher doses) and small sample size of the severe category. A prospective, randomized study would be useful in further evaluating the effectiveness of bronchodilator dosing strategies in reversing acute asthma symptoms.

OF-99-139

STAFFING FOR A RESPIRATORY CARE INTENSE STUDY DESPITE A HIGH VACANCY RATE,

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BACKGROUND: We were introduced to a partial liquid ventilation study (PLV) in the fall of 1998. This study is extremely respiratory intensive, with the instillation of liquid being maintained at a very specific level for forty-eight to one hundred twenty hours, requiring one-on-one care from a Respiratory Care Practitioner (RCP).

METHOD: We have a very active respiratory department with 100 RCPs covering eight intensive care units and ventilating more than two thousand patients per year. On top of this workload, our department has consistently operated with a fifteen percent vacancy rate for the past year. Because of the intensity of the PLV study, we initially felt it would be time prohibitive for us to participate in a study such as this. Our normal staff workloads would impede the unit RCP from spending the necessary time with the PLV patient. However, after much creative thought, we came up with a plan of action that has proven to be extremely successful! We asked our staff for volunteers interested in compromising the team that would care for patients enrolled in this study. Thirteen RCPs were chosen to make up this team, educated on the details and strict adherence of the study and scheduled, over and above their budgeted hours, so one RCP is on-call twenty four hours a day, seven days a week (they are paid from the PLV study budget). When a PLV patient is enrolled, the on-call PLV RCP comes in to take care of the PLV patient one-on-one for the duration of the patients course on liquid.

In order to make the protocol more user friendly for the RCP, branch logic diagrams were extrapolated from the protocol. The diagrams were designed to make the bedside application of the protocol smoother and to be a quick resource for the RCP. Tables were also designed to make the required date gathering more concise and ready for the statistician.

RESULTS: The implementation of this study protocol at our institution has been a tremendous success with a smooth course. It is our belief that this path has been so smooth as a result of the user friendly resources made available to us.

CONCLUSIONS: With much creative thought, labor intense, respiratory care, studies such as PLV can be successfully undertaken despite high vacancy rates.

OF-99-138

WEANING OUTCOMES REPORTED BY A REHABILITATION AND RESTORATIVE CARE CENTER'S LONG TERM VENTILATOR WEANING PROGRAM.

Mark A. Rinaldi, RRT. Drake Center, Cincinnati, Ohio.

BACKGROUND: To determine the rate of successful outcomes of a long-term ventilator-weaning program using a multi-discipline approach and the Siemens Servo 300 ventilator. METHOD: 150 patients who were transferred from acute care facilities for placement in a long term ventilator weaning program were followed for a 365 day period at the Drake Center, a long term Rehabilitation and Restorative Care center. A retrospective chart audit was performed to determine the utilization of weaning mode (i.e., SIMV vs. Volume Support) and the associated outcomes as it related to overall success, gender and average length of stay. RESULTS: Of the 150 patients followed, 13 were omitted due to a neuromuscular dysfunction, while 5 patients received "No Trial" resulting from the gravity of their medical condition. They consequently were identified as a separate sub-group. Of the 137 patients remaining in the study, 8.8% were weaned via SIMV; 87.5% via Volume Support and 3.7% received no trial. Successful weaning outcomes were reported at various cutoff values: Day 1 (all patient inclusive) = 74.01%; Day 5 = 73.95%; Day 10 = 73.19% and Day 14 = 69.23%. The average length of stay by gender revealed females at 34.1 days with males at 37.6 days. The length of stay by success/failure is 30.2 days and 45.9 days respectively, with overall length of stay at 36.0 days. CONCLUSION: Utilization of a multi-disciplined approach in conjunction with weaning via the Volume Support mode of the Siemens Servo 300 appears to be an effective regimen in the treatment of the difficult to wean ventilator dependent patient.

OF-99-184

STAFF TO PATIENT RATIO DURING EXERCISE SESSIONS IN OUTPATIENT PULMONARY REHABILITATION Phillip D. Hoberty, ED.D., R.R.T., Carol Chiu, B.S., R.R.T., Rebecca J. Hoberty, B.S., R.R.T., and Philip T. Diaz, M.D. The Ohio State University, Columbus, OH.

Background: There is no published standard for the ratio of staff to patients during exercise sessions in outpatient pulmonary rehabilitation. The lack of a standard raises concern about patient safety and the ability of the staff to supervise and monitor patients adequately. **Methods:** To determine if a staff to patient ratio standard exists, the directors of the 46 outpatient pulmonary rehabilitation programs in Ohio were surveyed. Directors of 40 (87%) responded, and the responses from the 36 who conducted pulmonary exercise sessions separately from cardiac sessions were analyzed. The size of the programs ranged widely from serving 100 patients/week down to 2 patients/week. **Results:** The maximum number of staff in an exercise session was 2, with a median of 1. The maximum number of patients in a session was 20, with median of 4. This resulted in a calculated 1:4 staff to patient ratio. Program directors were also asked to rank the importance of 8 factors in determining the reported ratio. From highest to lowest importance the factors were ranked: patient safety (which 55% of directors rated as first in importance), severity of pulmonary disease, availability of space or equipment, entry test data, pulmonary diagnosis, presence of cardiac problems, convenience, and other. Sixty percent of programs restricted the number of patients in their exercise sessions based on their staff to patient ratio. **Conclusion:** A state-wide standard has been determined from practice. Exercise staff work with small groups with a ratio of about 1:4 in order to assure patient safety, deal with patients' health problems, and provide adequate facilities. A majority of programs restrict the number of patients per staff to maintain a prescribed ratio during exercise.

OF-99-220

A CONTINUOUS QUALITY IMPROVEMENT PROJECT: ASSURANCE OF CONTINUITY AND STANDARDS OF RESPIRATORY CARE. Mary Kay Hamby RRT, RPFT and Peggy McDonagh Bravo RN, BSN Chelsea Community Hospital, Chelsea, Michigan.

Background: In an effort to respond to the increasing patient volume in Emergency Services and the waning of acute care patient volume, Chelsea Community Hospital implemented a cross training of Respiratory Therapists to the role of ER technician. Respiratory Therapists report to and provide care in Emergency Services from 5:30pm to 11:30pm. A Respiratory Therapist is on call for the night shift. As a result, Nurses on the Medical-Surgical, IC/CCU, Head Pain, Rehab and Behavioral Health Units are required to perform tests and treatments typically provided by the Respiratory Therapist.
Method: The Hospital Corporation of America method entitled FOCUS-PDCA was utilized to develop the improvement process. A survey of nurses was conducted addressing subjective data related to comfort levels and knowledge of nurses performing Respiratory tests/procedures. Questions were scaled using a 5 point scale with 1=strongly agree, and 5=strongly disagree. Data was analyzed using statistics of count and percentage. Surveys were utilized as measurement tools several times during the improvement process.
Results: Clarification of the need to improve the process was confirmed by the survey results. 32% of nurse respondents felt they were provided with proper instruction on how to perform respiratory tests/procedures. In an effort to improve the proficiency and confidence level of nurses to perform the tests/procedures, it was decided an educational forum was needed. Five rotating stations entitled NMT, ECG, Airway management, ABG and Tracheostomy Care comprised the "Respiratory Fair". Various preferences in learning including lecture, interactive discussion, redemonstration and self-paced reading were utilized to promote retention of content. Standardized format competencies with specific objectives were developed to accompany each station. Post evaluations indicated 100% of respondents felt program objectives were achieved, 100% felt the information provided was useful on a personal and professional level and 100% would recommend the Respiratory Fair to others. The process was re-evaluated with a 4-month post survey. To site a question posed to the staff, "Do you feel comfortable performing the NMT procedure?" 92% of the nurses who attended the Respiratory Fair strongly agreed to their comfort level whereas only 54% who did not attend the Respiratory Fair strongly agreed.
Experience: It is necessary to communicate and work as an interdisciplinary team to continue to achieve high standards of patient care. This was a positive experience in that Respiratory Therapists and Nurses have a better understanding of the collaboration required to achieve our hospital goal of continuity of patient care.
Conclusions: The Respiratory Fair coordinated by Respiratory Therapists and Nurses achieved the team goal to assure continuity in the provision of patient care by educating caregivers in a consistent manner. The clinical competency tools allow the ability to teach and evaluate proficiency of regular staff and new employees on an on going basis. The results indicate a favorable perception of the Respiratory Fair program among the responding nurses. The respondents supported an offering of the Respiratory Fair on an annual basis.

OF-99-223

SQUEEZING TECHNIQUE REDUCE PULMONARY COMPLICATIONS THAN CHEST WALL PERCUSSION IN CRITICALLY ILL PATIENTS. Tetsuo Miyagawa Ph D, RRT, PT, RCET; Department of Physical Therapeutics, College of Medical Sciences, Showa University, Yokohama, 226-8555, Japan.

Background : A large number of papers have been reported that conventional chest physical therapy failed to improve in critically ill patients. Particularly, Trendelenburg position and chest wall percussion were the cause of hypoxia, arrhythmia, bronchospasm, increase in intracranial pressure and pain. I have already reported the results of meta-analysis in cardiopulmonary physical therapy, which chest wall percussion is ineffective, combined aerosol therapy and chest PT was more effective than chest PT. The purpose of this study was to compare the effect of squeezing and percussion in critically ill patients. **Method :** I instructed registered nurses in two hospitals about chest PT before this study. However, the effect of percussion and squeezing were blinded. STUDY 1: Sixty one patients undergoing thoracic or abdominal surgery were randomized into two groups. The first group (n=32) received modified drainage position with squeezing and the second group (n=29) treated drainage position with percussion. I compared the number and duration of atelectasis or pneumonia and length of ICU stay. STUDY 2: One hundred sixty one patients admitted by trauma or cerebral vascular accident were randomized into two groups, which were squeezing group (n=80) and percussion group (n=81). I compared the same parameters as study 1. STUDY 3: I determined the effect was based on examination of the effect size (ES) or Odds ratio of study 1 and 2. **Results:** The duration of atelectasis or pneumonia was significantly shorter in squeezing group (2.4 ± 3.4 days) than percussion group (3.6 ± 3.0 days) in STUDY 1 ($p<0.05$). The length of ICU stay significantly reduced in squeezing (3.3 ± 2.5 days) compared with percussion (4.6 ± 2.4 days) in STUDY 1 ($p<0.05$). In the STUDY 2, the duration of atelectasis or pneumonia was also significantly shorter in squeezing (7.4 ± 3.7 days) than percussion (13.4 ± 3.6 days) ($p<0.001$). The length of ICU stay significantly reduced in squeezing (9.7 ± 2.2 days) compared to percussion (16.5 ± 3.4 days) ($p<0.001$). Odds ratio of atelectasis and pneumonia in study 1 and 2 was as follows. **Conclusions:** 1) Squeezing technique significantly reduced the number of pulmonary complications more than chest wall percussion in critically ill patients. 2) Squeezing technique reduced the duration of atelectasis more than chest wall percussion in critically ill patients. 3) Squeezing technique reduced the length of ICU stay more than chest wall percussion in critically ill patients.

	squeezing	percussion	Odds ratio	95%IC
study 1	32	29	0.21	0.06~0.68
study 2	80	81	0.62	0.33~1.16
Total	112	110	0.48	0.28~0.84

OF-99-227

EVIDENCE-BASED MEDICINE IN CARDIOPULMONARY PHYSICAL THERAPY. Tetsuo Miyagawa, PhD, RRT, PT, RCET ; Department of Physical Therapeutics, College of Medical Sciences, Showa University, Yokohama, 226-8555; Japan.

Background: Many of the techniques of chest physical therapy (Chest PT) for chronic respiratory disease were first described in the early 1900s and these methods have remained remarkably unchanged since then. However, It is still unclear whether many techniques are effective. because a large number of papers have been reported that conventional Chest PT was associated many complications. The purpose of this study was to determine the effect of cardiopulmonary physical therapy techniques on the evidence-based medicine.

Method: Computerized bibliographic data bases (MEDLINE) were searched from 1966 to 1997. For this search I used the following items: chest physical therapy (physiotherapy), postural drainage, diaphragmatic breathing, breathing retraining, incentive spirometry (IS), positive expiratory pressure (PEP), flutter valve, autogenic drainage and early mobilization.

Results: 1948 citations were found using the search strategies for primary research. I selected 42 trials for postoperative complication and acute respiratory failure and 41 trials for chronic respiratory failure. The analysis was based on examination of the effect size (ES) or Odds ratio (OR). 1) Chest PT decreased oxygenation in acute respiratory failure, ES -0.31(-0.57~ -0.05). 2) Chest PT was not effective for postoperative pulmonary complications, OR 0.80 (0.57~1.13). 3) IS and diaphragmatic breathing was effective for post operative pulmonary complications, OR 0.41 (0.25~0.68), OR 0.2 (0.11~0.36). 4) CPAP mask was more effective than chest PT in postoperative pulmonary complications, OR 0.49 (0.28~0.87). 5) Chest PT, IS or early mobilization did not reduce hospitalization, ES 0.09(-0.11~0.29), ES 0.28(0.04~0.53), ES 0.15(-0.20~0.50). 6) Comprehensive cardiopulmonary PT reduced postoperative pulmonary complication and hospitalization, OR 0.02 (0.16~0.30), ES 0.63(0.52~0.74). 7) Chest PT increased sputum expectoration in chronic respiratory failure, ES 2.23(1.76~2.70). 8) Percussion or vibration was not effective in chronic respiratory failure, ES 0.2(-0.10~0.50). 9) Combined aerosol therapy and Chest PT was more effective than chest PT in chronic obstructive pulmonary disease. ES1.46 (0.72~2.18). 10) Chest PT, PEP, huffing, cough, exercise, flutter valve and autogenic drainage were the same effects of sputum expectoration volume in chronic obstructive pulmonary disease.

Conclusions: Conventional Chest PT that included postural drainage, percussion and vibration was not effective. These results suggested more comprehensive cardiopulmonary PT was effective.

OF-99-228

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EVALUATION OF THE EFFECTS OF DELIVERING NITRIC OXIDE USING AN OXYHOOD INSIDE AN INCUBATOR

Michael Tracy, RRT, Robert L. Chatburn, RRT, FAARC
University Hospitals of Cleveland, Ohio

BACKGROUND: Previous work at our institution demonstrated that nitric oxide / oxygen (NO / O_2) mixtures could safely and effectively be delivered via oxyhood in an open environment. The purpose of this study was to determine if NO / O_2 mixtures could be delivered into the enclosed environment of a neonatal incubator and to determine the potential environmental threat outside of the incubator.

METHODS: An oxyhood (7"x7"x7" Nova Tent House, Nova Health Systems, Blackwood, NJ) was set up with FIO_2 0.40 and a flow of 15 L/m and NO concentration of 40 ppm. The hood was placed inside a Cara Plus Isolette (Ohmeda, Madison,WI) neonatal incubator. An INOvent (INO Therapeutics, Clinton, NJ) was calibrated according to the manufacturer's instructions. The injector module was placed on the inlet side of the humidifier and the sample line was suspended in the center of the oxyhood to verify NO concentration. Single measurements were made after a 5 minute stabilization period. Data were first collected inside the hood then 10cm from the hood (inside the incubator). Finally, environmental data were collected from outside the incubator under simulated patient care conditions.

RESULTS: Study data are shown below:

Environmental Exposure Data

location	NO	NO_2
10 cm from hood opening	25	0.3
Inside at top of incubator	12	0.3
10 cm above incubator	0.6	0.0
At open port (no sleeve)	2.2	0.0
At open port, hood up	9.0	0.1
At open door	1.2	0.0
At open door, hood up	2.5	0.0

Under all simulated patient care conditions, NO / NO_2 concentrations outside the incubator remained under OSHA exposure limits (time weighted average NO = 25ppm, NO_2 = 3ppm; peak exposure level NO = 25 ppm; short term exposure level NO_2 = 5ppm).

CONCLUSIONS: Oxyhood delivery of NO / O_2 mixtures is not affected by an incubator. There is no environmental exposure threat posed by delivering NO / O_2 mixtures via oxyhoods inside an incubator.

OF-99-022

STABILITY OF NITRIC OXIDE CONCENTRATION WHEN NITRIC OXIDE IS INJECTED CONTINUOUSLY INTO AN ADULT VENTILATOR CIRCUIT BEFORE THE HUMIDIFIER

Bob Somerville RRT, Kelly Jager RRT, Neal Querengesser RRT, Juan Ronco MD. Vancouver Hospital & Health Science Centre, Vancouver, Canada.

Background: Among the various systems used to deliver inhaled nitric oxide (NO) to ventilated adults, the most accurate and consistent is a pre-ventilator blended system. However, this set-up utilizes large amounts of NO. Instead, continuously injecting NO into the inspiratory limb of the circuit spares NO use but delivers very unstable NO concentrations [NO] when analyzed with a fast response NO analyzer. [NO] could be more stable if appropriate mixing is allowed before reaching the patient. We hypothesized that when NO is injected within the inspiratory limb proximal to the humidifier, [NO] will be more stable. Thus, the purpose of this study was to evaluate the stability of [NO] using both a fast (NOA, Sievers) and slow response NO analyzer (Sensornox, Sensormedics) when NO was continuously injected into the inspiratory limb prior to the humidifier. **Method:** An NPB 840 ventilator was attached to a 2-chambered test lung configured to separate inspired and expired gases. NO was continuously injected into the circuit, first, at the ventilator output and then just before the humidifier using a high-precision low flow flow-meter. [NO] and nitrogen dioxide (NO2) concentrations were measured from the inspiratory limb just before the Y piece. The ventilator was set to deliver either constant flow/volume breaths or pressure control breaths, with TV's of 0.5L and 1.0L and inspiratory times of 1 and 2 seconds. [NO] was 5, 20 and 40 ppm and the baseline settings of: volume control with Ti 1.0 second and TV of 1.0 L. Results: [NO] varied both within the breath and when ventilator settings were changed. At 5ppm, total range of [NO] from both injection sites was 2.1-16.2; at 20ppm, 4.6-58.2; and at 40ppm, 14.9-111.5ppm. The mean [NO] from the NOA was similar to that seen on the Sensornox (p=0.428). **Conclusion:** The humidifier does not act as a sufficient mixing chamber and therefore, NO should not be continuously injected into the inspiratory limb of an adult circuit before the humidifier. Variations are less when injection takes place at the ventilator outlet but remain unacceptable.

Mean NO during volume control and pressure control ventilation using both analyzers when **20 ppm** NO was continuously injected into inspiratory limb just before the humidifier.

Mode	Ti	Vt	(NO)	NOA	SEN
VCV	1	0.5	Mean	**53.7**	51
		1.0	Mean	**19.9**	20.0
	2	0.5	Mean	**54.9**	52.6
		1.0	Mean	**26.6**	27.2
PCV	1	0.5	Mean	**43.8**	44.8
		1.0	Mean	**13.6**	12.8
	2	0.5	Mean	**39.7**	39.8
		1.0	Mean	**18.1**	17.5

OF-99-056

EVALUATION OF OXYHOODS FOR THE DELIVERY OF NITRIC OXIDE

Michael Tracy, RRT, Timothy Myers, RRT, Robert Chatburn, RRT, FAARC
University Hospitals of Cleveland, Ohio

BACKGROUND: Typically nitric oxide (NO) is delivered into a closed ventilator circuit ensuring adequate mixing. Injection of NO into an open system like an oxyhood might result in stratification of gases due to differing molecular weights or the production of unacceptable levels of nitrogen dioxide (NO_2). The purpose of this study is to determine the feasibility of delivering NO via oxyhoods.

METHODS: A 12"x12"x12" hood (Nova Tent House, Nova Health Systems, Blackwood, NJ) with a simulated patient was set up with a 15 L/m flow and FIO_2 0.40. The injector module of an INO-vent (INO Therapeutics, Clinton, NJ) was placed on the inlet side of the humidifier. Nine sample lines were suspended inside the hood at the front, middle, back and bottom, middle top positions to sample NO, nitrogen dioxide (NO_2) and oxygen. Multiple sample lines were used to prevent sampling inaccuracy caused by repeated opening of the test system. The INO-vent was calibrated according to the manufacturer's instructions. Data were collected for the delivery of 1, 5, 10, 20, and 40 ppm of NO, in that order at each of the nine points in the hood. Each time a new sample line was connected the INO-vent values were allowed to stablize for 5 minutes before data was collected.

RESULTS: Gas concentrations at various locations are given in the table for 40 ppm NO. These data are shown because they represent the maximum NO_2 production and the greatest O_2 dilution. In all experimental conditions, the mean difference in gas concentration among all locations was 1ppm. The lowest FIO_2 and the highest NO_2 were associated with the highest NO concentration.

NO / NO_2 ppm	back	middle	front
top	38 / 1.5	38 / 1.5	39 / 1.5
middle	39 / 1.5	39 / 1.5	39 / 1.5
bottom	38 / 1.6	39 / 1.6	39 / 1.5

CONCLUSIONS: Injection of NO into an open oxyhood with an FIO_2 = 0.40 results in homogenous distribution of NO and acceptable levels of NO_2.

OF-99-023

THE EFFECTS OF HIGH FREQUENCY OSCILLATORY VENTILATION ON THE DELIVERED CONCENTRATION OF INHALED NITRIC OXIDE

Angela L. Sproles, BS, RRT, Shaina K. Bearman, BS, RRT, Amee J. Minton, BS, RRT, *Richard J. Hooper, RRT, Lisa R. Stillerman, MS, RRT, Indiana University School of Allied Health Sciences, Respiratory Therapy Program and *Riley Children's Hospital, Clarian Health Corporation, Indianapolis, Indiana.

Background: Nitric oxide (NO) has been the focus of intense clinical and laboratory studies for the treatment of persistent pulmonary hypertension of the newborn (PPHN). High frequency oscillatory ventilation (HFOV) is commonly used in conjunction with NO to treat PPHN. Since limited data is available concerning the use of NO with HFOV, this study was designed to determine the effects of clinically relevant ventilator parameters on the delivered nitric oxide concentration during HFOV. **Methods & Materials:** NO was injected by the INOvent delivery system (INO Therapeutics) into the inspiratory limb of a SensorMedics 3100A HFOV ventilator circuit. The ventilator was set at a constant I-time% of 0.33 and bias flow of 15 lpm. Independent variables were amplitude (0, 20, 25, and 30 cm$H_2$0), mean airway pressure (10, 15, and 20 cm$H_2$0), frequency (5, 10, and 15 Hz), FIO_2 (.21, .50, and 1.0), humidity (dry gas vs. heated, humidified gas), and NO setting (10, 20 and 40 ppm). Variables were manipulated independently and sequentially. All ventilator parameter adjustments were made with a dry gas circuit in place and then repeated in the same sequence with heat and humidity applied to the circuit. Delivered [NO] was measured at the patient connection for each of 864 combinations of these variables. The study was replicated a total of three times. **Results:** The response variable considered was the relative deviation between NO setting and delivered [NO]. The majority of the observations fell between ±2.5% of the target settings. Analysis of variance revealed a significant difference in group means, $F(13, 2578)=45.50$, $p<.01$. Multiple regression ($R^2 = 0.186$, MSE = 0.053) was performed to eliminate the non-contributory variables which were found to be frequency and mean airway pressure. **Conclusions:** Independent changes in FiO_2, amplitude, NO setting, and humidity produce small, but statistically significant variations in the concentration of nitric oxide delivered with the INOvent system during HFOV. The majority of these deviations are small, however those greater than ± 5% can be attributed to specific combinations of variables. There were also significant correlations between the different levels within each of the four contributing variables. These variations become more clinically significant at lower nitric oxide settings.

OF-99-076

LOW DOSE AND LIMITED DURATION (≤ 4 DAYS) INHALED NITRIC OXIDE SAFELY REDUCES THE USE OF ECMO IN NEONATES WITH HYPOXEMIC RESPIRATORY FAILURE AND PULMONARY HYPERTENTION

Reese H. Clark, MD, Pediatrix Medical Group, Fort Lauderdale, FL., Thomas J. Kueser, MD and Lucy J. Linder, RRT, Carolinas Medical Center, Charlotte, N.C.

Background:
The purpose of our study was to determine if nitric oxide reduced the use of extracorporeal membrane oxygenation (ECMO) in neonates with severe pulmonary hypertension. We conducted a blinded, multi-center, randomized, controlled trial that compared placebo (nitrogen, FI02 = 0.98) to low dose inhaled nitric oxide (maximum dose of 20ppm, FI02 = 0.98)
Method:
Neonates born after 34 weeks of gestation, who were 4 days old or less, required assisted ventilation and had an oxygen index of ≥25, were eligible for enrollment. All infants had to have a clinical or echocardiographic evidence of pulmonary hypertension. The infants were stratified by diagnoses and randomly assigned to placebo or treatment with inhaled nitric oxide. Treatment with inhaled nitric oxide was strictly defined; 20ppm for maximum of 24 hours, followed by 5ppm for not more than a total of 96 hours.
Results:
Baseline clinical characteristics were similar in the 122 patients in the placebo group and the 126 in the nitric oxide group. ECMO was used in 64% of the patients assigned to control and in only 38% of patients treated with inhaled nitric oxide (P=0.001). Mortality during the first 30 days of life was statistically the same in both groups (8 vs. 7% placebo vs. nitric oxide). Oxygenation, as assessed by changes in arterial to alveolar oxygenation ratio, improved more rapidly over time in patients treated with nitric oxide. There were no differences in the occurrence of intracranial hemorrhage, seizures requiring treatment, duration of mechanical ventilation or length of stay between the two groups. Neonates treated with inhaled nitric oxide developed chronic lung disease less often than neonates assigned to placebo (20 vs. 7%,p=0.02, placebo vs. nitric oxide).
Conclusions:
Inhaled nitric oxide safely reduced the use of ECMO in near-term to term neonates with severe pulmonary hypertension.

OF-99-085

LAB EVALUATION OF NITRIC OXIDE VIA NASAL CANNULA UTILIZING THE DATEX-OHMEDA INOvent.

John Newhart CRTT, RCP., Arthur Smerling M.D., Danielle Rice, Richard N. Channick M.D., UCSD Medical Center, San Diego, Ca., and The Babies Hospital at Columbia Presbyterian, New York, NY.

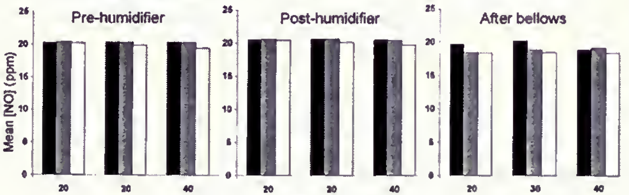
Background: Inhaled Nitric Oxide (INO) has been shown to be a selective pulmonary vasodilator and has been used post-op on cardiac surgery patients. In our institutions INO is most frequently administered in conjunction with mechanical ventilation with the Datex-Ohmeda INOvent. In some instances it has been necessary to continue INO therapy after the patient has been weaned from mechanical ventilation. We tested the performance of the INOvent adapted to a nasal cannula. This would give us the flexibility to use the same NO delivery device for both spontaneously breathing and ventilator dependant patients. Description: The INOvent is a self-contained delivery and monitoring system. It incorporates a flow sensor/injector module. For spontaneously breathing patients INO is administered via a nasal cannula. **Methods:** A flowmeter is incorporated to control a carrier gas (21-100% O2) at 2-8lpm through the flow sensor into a mixing tube and into a standard nasal cannula. Gas is sampled at the exit of the mixing tube for NO, NO2 and O2. For purposes of this study the gas was sampled at the end of a 7' long piece of small bore O2 tubing, simulating the end of a nasal cannula. By adjusting the flowmeter and the INOvent NO dose setting, delivered NO concentration and oxygen/NO flow rate can be adjusted **Results:** Flowmeter settings of 2-8 lpm (O2 or air) can deliver 20 and 40ppm NO continuously through a standard nasal cannula. Flowmeter settings of 7-8 lpm (O2 or air) can deliver 80ppm NO continuously through a standard nasal cannula. NO2 levels remained well below the EPA standard of 5ppm as well as below our institutional standard of 2ppm. Limiting factors that were identified during testing include: 1) 80ppm could not be maintained with flow meter settings below 7 lpm. 2) Flow meter settings below 2 lpm resulted in erratic NO readings. **Conclusion:** INO via nasal cannula can be easily and safely accomplished utilizing the INOvent.

OF-99-131

NITRIC OXIDE DELIVERY DURING HIGH FREQUENCY OSCILLATION (HFO).

Yuji Fujino, MD, Robert M Kacmarek, PhD RRT FAARC, Dean Hess, PhD RRT FAARC. Departments of Respiratory Care and Anaesthesia, Massachusetts General Hospital and Harvard Medical School, Boston MA.

Background: We have previously investigated the fluctuation of nitric oxide concentration ([NO]) during inhaled NO therapy with conventional mechanical ventilation (Anesthesiology 1997;86:676 and Chest 1998;133:1650-1657). However, no study has reported the accuracy of NO delivery during HFO to determine whether [NO] fluctuates beyond the clinically acceptable range. The aim of this study was to evaluate the mixing of NO titrated into the HFO ventilator circuit at different sites using a rapid response [NO] analyzer. Method: An oscillator (Sensormedics 3100A, Yorma Linda CA) was set up in the usual manner to ventilate a test lung (compliance ≈1 mL/cm H_2O). NO (800 ppm) was titrated into the circuit pre-humidifier, post-humidifier, and after the bellows. Target [NO] was adjusted using a calibrated rapid response analyzer (Sievers NOA 280, Boulder CO) without oscillation at 5, 10, 20 ppm. The ventilator was set at FIO_2 0.9, inspiratory fraction 33%, bias flow of 20 L/min, and all combinations of frequency 5, 10, 15 Hz; mean airway pressure 15, 20, 25 cm H_2O; and amplitude 20, 30, 40 cmH_2O. Gas was sampled and [NO] measured with the rapid response analyzer either 5 cm from the bellows (proximal), 35 cm from the bellows (mid), or at the distal end of the circuit (distal). The INOvent Delivery System (Datex-Ohmeda, Madison WI) was evaluated in a similar manner (pre-humidifier injection site only). [NO_2] was measured with a calibrated electrochemical cell (INOvent). Results: The figure shows target [NO] of 20 ppm, frequency 10 Hz, and mean airway pressure 20 cm H_2O (closed bars for proximal sampling, gray bars for mid-sampling, and open bars for distal sampling). With NO injection after the bellows, the delivered [NO] at the mid and distal sampling sites was lower than target [NO] (> 5%). The INOvent delivered virtually the target [NO] at all conditions. The [NO_2] was <1 ppm for all settings. Conclusions: Mixing of NO was satisfactory, particularly when NO was titrated into the circuit before the humidifier. Comparable results occurred with the INOvent and titration of NO into the circuit. The levels of NO_2 were low and acceptable.



OF-99-120

EVALUATION OF A CHILD FOR HOME INHALED NITRIC OXIDE THERAPY

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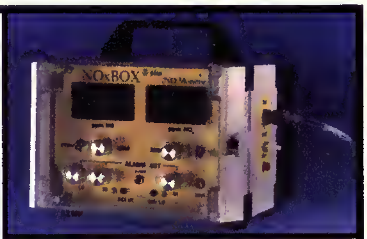
Departments of Respiratory Care and Cardiology, Children's Hospital and Department of Pediatrics, Harvard Medical School, Boston, MA-

Long-term inhaled nitric oxide (INO) is being investigated as a therapy in the management of chronic pulmonary hypertension[1]. We evaluated the use of INO in a child with pulmonary hypertension in order to determine the feasibility of long-term therapy in the home. A 4 year old male was diagnosed with an atrial septal defect (ASD) and patent ductus arteriosus (PDA), with pulmonary artery pressures (PAP) equal to systemic arterial pressure (SAP), and right-to-left shunting in room air. Following demonstration of pulmonary vascular reactivity with INO, the PDA was closed with a device and PAPs decreased to 2/3 of SAP. In preparation for later closure of the ASD, INO in conjunction with Heparin, was started with the hypothesis that this therapy would aid in the remodeling of pulmonary vessels and effect further reduction of PAP. INO at 50 ppm, by nasal cannula (NC), was administered by mixing 0.5 L/min of O_2 with 0.5 L/min of nitric oxide (NO) from a 100 ppm NO cylinder. In the event of an inadvertent cylinder leak, a 100 ppm source was deemed safe for a non-ICU setting. Echocardiography demonstrated left-to-right shunt flow through the ASD while on INO; SpO_2 was 92-98%. Anticipating home therapy, daily simulations of INO disconnection were performed and resulted in acute decreases in SpO_2 to 50-60% despite O_2 therapy. Echocardiography and cardiac catheterization subsequently showed PAP > SAP during INO withdrawal. Trial doses of Sildenafil[2] and Dipyridamole[3], both cGMP degradation inhibitors, were administered to minimize the rebound effect. Sildenafil blunted the rebound with SpO_2 > 90% off INO, but Dipyridamole did not. After 7 days a cardiac catheterization demonstrated that PAPs equaled SAP. To optimize INO delivery, 40 ppm by a tight-fitting mask replaced the NC, and the PAPs decreased to < 1/2 SAP. The ASD was left open. The patient was intubated and ventilated with 40 ppm INO in order to ensure adequate alveolar concentrations of NO. After 5 days the patient was extubated and continued on INO at 50 ppm by NC. INO was weaned over the next 7 days to a dose of 9 ppm. Once off INO, the patient's SpO_2 was 92-96% on 0.5 L/min O_2 with no acute changes in SpO_2. The maximum methemoglobin during INO therapy was 2.2%. The maximum nitrogen dioxide concentration during bench testing of the NC system, and during mechanical ventilation, was < 1 ppm. Follow-up echocardiography continued to suggest evidence of pulmonary hypertension. This patient was treated with INO for 21days in the hospital which was originally intended to be accomplished in the home. The significant rebound observed when INO was disconnected, demonstrates the importance of simulating INO disconnections and testing for rebound when anticipating home INO therapy. It is unclear if continued use of Sildenafil or Dipyridamole is feasible and will safely protect patients from adverse effects of inadvertent INO withdrawal. The patient was discharged with home O_2 and will be re-evaluated for ASD closure in the future. Domiciliary use of INO is investigational therapy. Safety and efficacy trials must evaluate known and unknown toxicities, adequacy and availability of home monitoring, limitations of NC delivery and physiologic response to inadvertent withdrawal. 1. Atz AM, Wessel DL. Inhaled nitric oxide and heparin for infantile pulmonary hypertension. Lancet 1998;351:1701. 2. Atz AM, Wessel DL. Sildenafil ameliorates the effects of inhaled nitric oxide withdrawal. Anesthesiology 1999;90 (in press). 3. Dunbar DD, Kinsella JP, et al. Dipyridamole attenuates rebound pulmonary hypertension after inhaled nitric oxide withdrawal in postoperative congenital heart disease. J Thorac Cardiovasc Surg 1998;115:875-82.

OF-99-144



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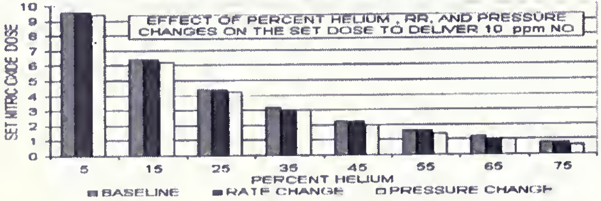
SIMULTANEOUS USE OF HELIOX AND INHALED NITRIC OXIDE (NO)

M Sinbal RRT, E Warnecke RRT, R Kraemer CRTT, Respiratory Care Services, S Sniderman MD, Department of Pediatrics, San Francisco General Hospital, University of Calif. San Francisco

Case Summary: A 1190 gm male infant was delivered by C-section at 27 weeks gestation secondary to placental abruption 9 weeks post maternal rupture of membranes. The infant was intubated at birth and received 4 doses of Survanta. Development of pulmonary interstitial emphysema ensued subsequent to lung hypoplasia and mechanical ventilation. Fifteen days after birth, HFV was initiated with an Infant Star ventilator for worsening respiratory acidosis and to prevent air leak syndromes. Heliox with conventional ventilation was instituted 9 days later following a rise in PaCO2 to 107 mmHg. Following initial improvement in ventilation and oxygenation with heliox, IV Decadron, and aerosolized Albuterol, desaturations with bradycardia occurred with increasing frequency. Eight days following the start of heliox the infant required 2 minutes of CPR for prolonged desaturation with severe bradycardia. Four days later, FDA approval for compassionate use of inhaled NO was obtained. NO was administered with the Ohmeda INOVENT delivery system. NO was started while heliox administration continued. An initial set dose of 5.4 ppm delivered a dose of 10 ppm because of the effect of helium on the accuracy of the INOVENT's flow injector module. Within 15 minutes the FiO2 was decreased from .80 to .60 which required an adjustment of the set NO dose to 2.6 ppm. The NO dose was subsequently titrated up to 15 ppm with a set dose of 3.5 ppm. This allowed a further reduction in FiO2 to .50 and required an adjustment of the set NO dose to 3.2 ppm to maintain dose delivery at 15 ppm. As FiO2 was reduced, the subsequent increase of the helium concentration, allowed a reduction in both ventilator rate and pressure. The respiratory status of the infant stabilized. Five days later heliox was discontinued. After three more days of NO inhalation, the dose was weaned over a three day period and discontinued. The infant was managed with conventional therapies and was weaned from the ventilator and extubated fifty six days later.

Discussion: The flow injector module of the INOVENT utilizes a heated wire ananometer to measure gas flow. The high thermal conductivity of helium cools the heated wire element more rapidly and causes calculations of higher flowrates than are actually delivered. This effect increases proportional to the concentration of helium in the gas mixture and results in higher NO dose delivery at any set dose. To maintain a constant NO dose delivery, any changes in FiO2 (and therefore the helium concentration), required adjustments in the set NO dose. The following chart quantifies this effect. Measurements were made on a test lung at baseline pressures=33/4, RR=44, insp. time=.44 seconds, and with a rate change to RR=20, and pressure change=20/4.

Conclusion: NO dose delivery of the Ohmeda INOVENT is affected by simultaneous use of heliox but appears to remain stable while varying rate and pressure during heliox delivery.



OF-99-167

Effect of Altitude on Four Inhaled Nitric Oxide Monitoring and Two Delivery Devices

Mark Rogers BS, RCP, RRT, Kathleen Adams RCP, RRT, Thomas Malinowski BS, RCP, RRT Loma Linda University Children's Hospital. Loma Linda, California.

Introduction: The use of inhaled nitric oxide (iNO) has been advocated for the treatment of pulmonary hypertension associated with ARDS and persistent pulmonary hypertension of the newborn. Delivery devices have been developed which allow the accurate monitoring and titration of nitric oxide (NO). Unfortunately, these system are large and bulky. This presents a problem for interfacility transport teams, as patients may need to be transported by aircraft while receiving the drug. We sought to compare the effects of altitude on a cohort of inhaled nitric oxide monitoring and delivery devices. **Methods:** We compared the NoxBox I (Bedfont Scientific Ltd.), Pulmonox II (Pulmonox Inc.), INOvent (Datex / Ohmeda) and the AeroNox (Pulmonox Inc.) NO and nitrogen dioxide (NO2) monitors. Additionally, we compared the delivery systems of the INOvent and AeroNox devices. Device comparison was a two step procedure; evaluation of the analyzation of a know concentration of NO and NO2 gas, and evaluation of the delivery of a specific concentration of NO at altitude. Each device was calibrated at ground level (1400 feet above sea level) per manufacturers instructions. All testing was performed in a Bell 222 helicopter which maintained each altitude for approximately four minutes. Monitor Test: A continuous flow CPAP circuit (20 cmH20) was fed with five LPM of calibration gas (20 PPM NO and 7.3 PPM NO2). Sample lines from each device were connected to the circuit. Data collection consisted of direct observation of monitored NO and NO2 at five altitudes. Devices were allowed to stabilize at each altitude prior to data collection. Delivery Systems: Delivery devices were set up per manufacturers instructions to deliver 20 PPM into a 10 LPM continuous flow circuit. Each delivery device was connected to an 800 PPM source gas. Data collection consisted of measured NO and NO2 at five altitudes. **Results:**

	Monitors								Delivery Systems			
Altitude	Pulmonox II		AeroNox		Bedfont		INOvent		AeroNox		INOvent	
(ft)	NO	NO2	NO	NO2	NO	NO2	NO	NO2	NO	NO2	NO	NO2
1400	20	7.3	20	7.3	20	7.3	20	7.3	20	0.2	20	--
3400	20	7.2	20	7.2	19.8	7.1	19	--*	21	0.2	20	--
5400	20	6.7	20	7.2	19.5	6.8	18	--	22	0.1	19	--
7400	20	6.5	20	7.1	19.1	6.5	17	--	24	0.1	18	--
9400	21	6.2	20	7.3	18.7	6.2	16	--	26	0.1	17	--

* NO2 cell of the INOvent failed during the test.

Discussion: Fuel cell technology routinely used in NO monitoring and delivery systems is susceptible to error at altitude. Manufactures contacted verify this as a potential limitation of this technology. The error observed with some monitoring and delivery systems may be clinically significant. Tolerable error for manufacturers may exceed acceptable clinical limits. Further investigation is warranted. Conclusions: Altitudes attained during air transport may result in variable performance characteristics of NO monitoring and delivery systems.

OF-99-168

OFF LINE EXHALED NITRIC OXIDE LEVELS AS A MARKER IN LUNG DISEASE.

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Department of Pulmonary and Critical Care Medicine, The Cleveland Clinic Foundation, Cleveland, Ohio 44195

Exhaled Nitric oxide (ENO) has been proposed as a noninvasive marker for lung disease. Currently there are two methods of measurement of ENO, (1) online direct-measurement as the patient exhales into the analyzer. (2) offline measurement of NO in exhaled gases collected in a reservoir bag. Offline measures are useful in that sampling can be performed at remote sites and stored for later measurement. We investigated the offline measurement from two Emergency Departments, one within our institution and the other a local Trauma center. Emergency room Personnel were trained in the procedure. We evaluated the data for reproducibility

Exhaled gases were collected into mylar balloons. The patient inhaled room air to total lung capacity then exhaled through a mouthpiece with 10 cm of PEEP as resistance to reduce nasal gas contribution to the sample, a known source of contamination. Two exhaled breaths were collected in mylar balloons with no breath hold, and two exhaled breaths were collected with a 15 second breath hold.

TABLE 1

GROUP	n	CORR	P VALUE	MEAN ±SE
BH #1	31	0.935	<0.001	25 ± 3
BH #2	25	0.935	<0.001	27 ± 4
NO BH#1	31	0.758	<0.001	24 ± 3
NO BH#2	24	0.758	<0.001	22 ± 2

Table one is the statistical results of 31 patients sampled. There was no significant statistical difference between the two sets of samples with and without breath hold. ENO can be measured offline using a mylar balloon collection technique with accuracy and reproducibility. This method may find future value as a marker for pulmonary disease.

OF-99-226

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INTERMITTENT NASAL CANNULA ADMINISTRATION OF NITRIC OXIDE RESULTS IN REDUCED LUNG EXPOSURE TO OXIDES OF NITROGEN AND LOWERED GAS CONSUMPTION

Miller CC, Mullin C, Levy R, Road J
Respiratory Division, Department of Experimental Medicine, University of British Columbia, Vancouver, B.C.,Canada

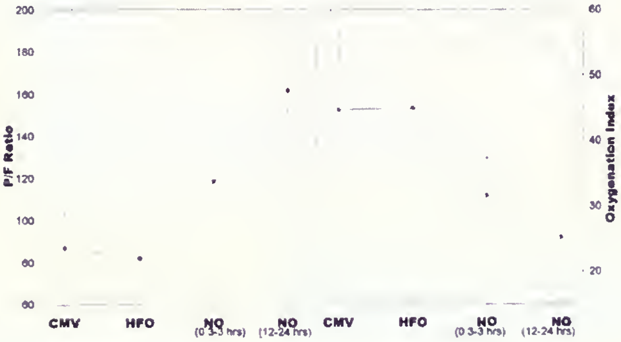
Introduction: A positive response to inhaled nitric oxide (NO) is a predictive screening tool for long-term treatment of primary pulmonary hypertension (PPH). This treatment consists of calcium channel blockers or prostacyclin. Both of these pharmaceuticals are not without side effects and limitations. Chronic administration of inhaled nitric oxide (NO) may be a beneficial alternative in treating PPH due to its vasodilator action, improvement of right ventricular performance and its antiproliferative effect on the pulmonary vascular smooth muscle. Evaluation of the safety and efficacy for long-term use of NO in treating patients with PPH has been hindered by the lack of information about NO delivery methods to spontaneously breathing humans. **Objectives:** The purpose of this study was to analyze the NO concentration profile in the human lung during both continuous and intermittent nasal cannula delivery during spontaneous breathing. **Methods:** Seven healthy volunteers (Ages 19 – 74, 5 males and 2 females) underwent bronchoscopy in order to sample baseline endogenous NO levels in the right middle lobe (RML), right upper lobe (RUL) and carina of the right lung with a rapid response chemiluminescence analyzer (280NOA, Sievers, Colorado, USA). The bronchoscope was in place in the right middle lobe during exogenous NO administration. NO was then delivered with a prototype delivery device (Pulmonox, Alberta, Canada) designed for the study. A source NO cylinder of 80 parts per million (Matheson, Alberta, Canada) was used in conjunction with the device to deliver NO via nasal cannula (Softech Bi-Flo cannula, Hudson RCI, California, USA) continuously (1.5 Lpm) or intermittently (0.8 s @ 5 Lpm) during normal tidal breathing. Additional data was collected to evaluate baseline lower airway NO utilizing the restrictive exhaled breath (REB) technique as described elsewhere in the literature. **Results:** An initial inspiratory NO peak was found in all breathing cycles during continuous and intermittent NO administration. The peak during continuous NO delivery was not significantly different (46.1; SD=21.8 parts per million) than during intermittent NO delivery (55.8; SD=24.8 parts per million). After the initial inspiratory peak during continuous NO delivery, a relatively stable plateau was observed in late stage expiration. This plateau was significantly lower with intermittent (0.7; SD=0.4 parts per million) as opposed to continuous (8.2; SD=3.2 parts per million) NO administration. Endogenous NO REB was significantly lower (16.4; SD=4.5 parts per billion) than endogenous NO at the RML (56.5; SD=20.1 parts per billion), RUL (71.4; SD=22.4 parts per billion) and carinal level (65.5; SD=24.3 parts per billion) of the lung. There was no significant difference between endogenous NO levels at the RML, RUL and carina (p>0.05). **Conclusion:** These results suggest that NO delivered during intermittent NO delivery effectively delivers a dosage beyond the RML similar to continuous NO delivery. This technique would reduce NO consumption and lower the overall exposure of the lung to NO during long-term NO administration to PPH patients.

OF-99-230

OXYGENATION RESPONSE TO INHALED NITRIC OXIDE (INO) WHEN COMBINED WITH HIGH FREQUENCY OSCILLATORY VENTILATION (HFOV) IN ADULTS.

R. MacDonald RRT, T. Stewart MD, D. Banayan, S. Lapinsky MD, M. Aubia RRT, S. Mehta MD. Mount Sinai Hospital, University of Toronto, Toronto, Canada.

During conventional mechanical ventilation (CMV) approximately 40 - 50% of patients with ARDS respond to INO. However as reported by Rouby et al, the response to INO is augmented when the lungs are optimally recruited **(ref.)**. Since High Frequency Oscillatory Ventilation (HFOV) in adults may be an optimal way to recruit the lungs we speculate that when INO is combined with HFOV the response rate may be improved. We evaluated the acute effect of INO on oxygenation in 6 adults (5F, 1M, age 42 ±19 yrs, APACHE II 29 ± 4) with ARDS while receiving HFOV. Parameters on CMV prior to HFOV: PaO_2/FiO_2 87 ± 40 mmHg, mean airway pressure (Paw) 27 ± 4 cm H_2O, oxygenation index $[OI=(FiO_2*Paw*100)/PaO_2]$ 45±29. Once patients were stabilized on HFOV (PaO_2/FiO_2 82 mmHg, Paw 35±4 cmH_2O, OI 45±16), INO was initiated at a dose of 14 ± 5 ppm and then titrated to 12 ± 8 ppm over 24 hours. We present PaO_2/FiO_2 ratios and OI during CMV, HFOV, and during the first 24 hrs of INO. Observations are grouped in intervals of elapsed time 0.3 – 3 hrs and 12 – 24 hrs. Patients were ventilated with HFOV for 34 ± 51 hrs prior to instituting INO. (All values mean ± SD).



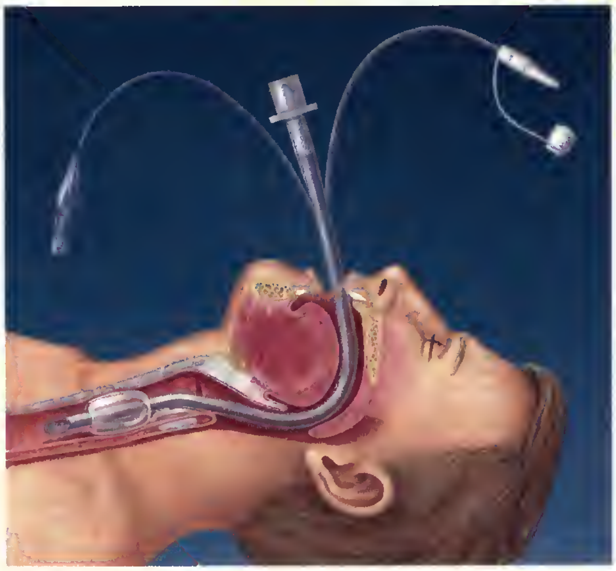
All 6 patients showed a ≥20% improvement in PaO_2/FiO_2 during INO, and a ≥ 18% improvement in OI. The average improvement in PaO_2/FiO_2 was 85%, and in OI was 42%. In conclusion, in these patients, INO delivered with HFOV had beneficial physiological effects. Further prospective evaluation is required.

Ref: Puybasset L, Rouby JJ, et al. Factors influencing cardiopulmonary effects of inhaled nitric oxide in acute respiratory failure. Am J Resp Crit Care Med 1995; 152:318-28

OF-99-232

MALLINCKRODT

Continuous Aspiration Of Subglottic Secretions Is A Simple Concept For Reducing The Incidence Of Ventilator-Associated Pneumonia.



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[1] Kollef et. al. Ventilator-Associated Pneumonia: An Update for Clinicians, Respiratory Care, 1995, Vol. 40, No. 11: 1130-1140.
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BEHAVIORAL RISK FACTORS OF NEAR-FATAL ASTHMA: A DOUBLE BLIND, CASE-CONTROL STUDY

Ronald R. Sanderson DrPH, RRT, Castle Medical Center, Kailua, HI; Walter Patrick MD, PhD; Carol Waslien PhD; Roy S. Adaniya MD, University of Hawaii, Honolulu, HI.

Problem statement: Asthma mortality is excessive and may be reducible. Behavioral risk factors for asthma death are difficult to identify, and are often too nonspecific to be of predictive value. Methods: A case-control study of 19 cases with near-fatal asthma who were matched for gender, age, asthma treatment and severity to 19 controls was used to examine behavioral, historical and symptomatic risk factors of near-fatal asthma. Subjects were a sample of all non-military, near-fatal asthma cases on the Island of Oahu, Hawaii. Age limits were 18 - 46 years. A professional interviewer administered three previously validated questionnaires, respiratory disease symptoms and history, psychological symptoms and social support. Both the interviewer and subjects were blinded to the subject's status as case or control. Results: Major findings include severe asthmatic controls under medicating compared to near-fatal asthma cases, and that they were otherwise very similar. As a study group the subjects (cases and controls) were more often low income, psychologically distressed, female and of Hawaiian ethnicity who are seeing a physician pulmonary specialist and being prescribed appropriate medications. Medication compliance was poor. Sixty percent of the subjects had at least one parent with asthma. Mean duration of asthma was 21.5 years. There was a very high (>16%) mortality rate among potential near-fatal asthma subjects. Discussion: These data suggest that restraint in anti-asthma medication use may protect severe asthma patients from near-fatal attacks. These data confirm the similarity of subjects with near-fatal asthma and severe asthma.

OF-99-008

EVALUATION OF A MEDICAL CENTER BASED ASTHMA EDUCATION PROGRAM

Ronald R. Sanderson DrPH, RRT, Karen Lee, RRT, Joseph Palma, M.D., Alan Yoneshige CRTT, Shary Hayashi CRTT, Castle Medical Center, Kailua, HI

Problem statement: National Asthma Education and Prevention (NAEP) guidelines state that quality of life can be improved for asthma patients with increased use of peak flowmeters and written asthma plans. Can respiratory care practitioners (RCPs) increase the number of written asthma plans and peak flowmeters among moderate and severe asthma patients?

Program description: Hawaii may have the highest asthma prevalence and mortality in the Nation. The windward side of Oahu has the highest asthma prevalence on the Island of Oahu and the largest number of asthma patients in Hawaii. Castle Medical Center, 120 beds, is the primary medical center for Windward Oahu, approximately 500-700 asthma cases are seen each year. In 1997 a comprehensive asthma program based on NAEP guidelines was implemented.

Methods: The Emergency Department (E.D.) was remodeled to optimize treatment of asthma. E.D. physicians, nurses and RCPs received training in asthma treatment according to NAEP Guidelines. Protocols for asthma treatment, education and data collection were implemented. Soon after E.D. discharge RCPs contact each asthma patient by telephone. The patient's primary physician is asked to order an Asthma Assessment and Education Session (AAES) by an RCP. Sixty-eight asthma patients received AAES.

Results: Major findings include 2.36 times increase in use of peak flowmeters, 4.47 times increase in use of written asthma management plans and increased use of anti-inflammatory medications.

Discussion: These data demonstrate that intervention by respiratory care practitioners can improve self-management of asthma. In turn this improved asthma management may reduce asthma morbidity.

OF-99-026

THE EFFECT OF IMPLEMENTING A COLLABORATIVE PRACTICE PROTOCOL ON PEDIATRIC PATIENTS ADMITTED WITH ASTHMA

Deb Bakalarski RRT, Rhonda Duerst RRT, Maureen Rich RRT, Karen Wendelberger MD. Children's Hospital of Wisconsin (CHW); Milwaukee, Wisconsin.

Background: Pediatric asthma hospitalizations continue to rise every year and have many variations of practice. This study evaluated the effect of implementing collaborative practice protocols to standardize care. **Methods:** After reviewing the literature; a scoring system, six protocols and an intensive training program were developed. The training included--assessment, scoring, protocol, algorithm and case study application. Starting in 1996, asthmatics were placed into protocol if they were on a specific floor and had a physician's order for protocol. The control group included patients who did not have an order or were admitted to other floors. Data elements included: length of stay, the time frame between admission, bronchodilator orders and treatments. In addition, data was obtained regarding cost, patients discharged within 36 hours and the initial frequency of the bronchodilator treatments. Data was examined using analysis of variance. Results are as follows:

Data Element	1996 (120 patients)		1997 (96 patients)	
	Protocol	Control	Protocol	Control
Average length of stay	32 hrs.	42 hrs.	34 hrs.	39 hrs.
Time between admit & orders	67 min.	89 min.	102 min.	98 min.
Time between orders & Tx	36 min.	67 min.	8 min.	57 min.
Time between ER & floor Tx	169 min.	218 min.	177 min.	249 min.
Cost of hospitalization			$2213	$2117
% of patients discharged within 36 hours			61%	38%
% of patients with initial Tx frequency of Q2 hours			32%	8%

Experience: In 1997, there was slow acceptance of the protocol program amongst the pediatric residents as CHW is a teaching facility. Then follow up data in 1998 revealed a lack of control patients due to the popularity of the protocol; therefore we were unable to duplicate the study. The initial frequency of treatments differed as the protocol group had more Q2 hour treatments compared with the control group that was started at Q4; possibly increasing the cost. With the success of the protocol it has been expanded to include post-op cardiovascular patients and a ventilator weaning protocol. **Conclusions:** By combining more aggressive care on admission and by decreasing the variances of care, the length of stay was reduced. The substantial education program for the RCP's prior to implementation ensured accurate and consistent use of the protocols.

OF-99-025

LOW DOSE FLOVENT ONCE OR TWICE DAILY VIA THE DISKUS IMPROVES LUNG FUNCTION AND MAINTAINS ASTHMA STABILITY IN STEROID-NAIVE ASTHMATICS.

Stuart Harding, MD; Abbas Hamedani, MS; and Anne Leslie Stevens, RRT, CPFT; GlaxoWellcome, Inc, Research Triangle Park, NC.

A 12-week, multi-center, double-blind, double-dummy, parallel-group trial compared the efficacy and safety of fluticasone propionate (FP), beclomethasone dipropionate (BDP) and placebo (PLA) in 299 male and female subjects aged 12 and up who were currently treated with bronchodilator therapy and who had not used inhaled corticosteroids (ICS) for at least one month prior to study enrollment. The DISKUS device, a breath-actuated 60-dose dry powder inhaler, was used to deliver treatments of FP 200mcg once-daily (FP-QD), FP 100mcg twice-daily (FP-BID) or placebo (PLA). A metered dose inhaler (MDI) was used to deliver BDP 168mcg BID. Subjects treated with FP-QD and FP-BID had mean changes from baseline at endpoint in FEV1 % predicted of 9.45% and 13%, respectively and BDP treated subjects had mean changes from baseline at endpoint of 12% ($p \leq 0.048$ vs. PLA). PEF was measured twice daily by subjects and FP-QD and FP-BID treated subjects demonstrated mean increases from baseline at endpoint of 27 and 31 L/min in AM PEF and of 26 and 25 L/min in PM PEF, respectively ($p \leq 0.009$ FP vs. PLA). Changes in AM and PM PEF in the BDP group were similar to those seen with FP treatment. At endpoint, mean total Ventolin use by subjects in all active treatment groups decreased significantly from baseline ($p \leq 0.019$ vs. PLA). Subjects were dropped from the study for lack of efficacy (LOE) when meeting pre-determined asthma stability criteria including lung function and symptom measures. Fewer subjects on FP-QD (n=7) and FP-BID (n=5) were dropped for LOE compared to PLA (n=19). Ten subjects on BDP were withdrawn for LOE and this was not significantly different from PLA. Frequency of adverse experiences (AEs) was similar across all treatment groups with the most frequently reported AEs involving the ear, nose, and throat body system. Data from these subjects with asthma previously treated with bronchodilator therapy only demonstrated that FP administered once or twice daily was effective in improving pulmonary function and maintaining asthma stability. Supported by GlaxoWellcome, Inc.

OF-99-031

Symposium #11: Treating Asthma

DOES NEBULIZER BRAND MAKE A CLINICAL DIFFERENCE IN THE EMERGENCY ROOM MANAGEMENT OF PEDIATRIC ASTHMA?

Timothy R Myers RRT, Robert Chatburn RRT, Marsha Rogers CRTT, Karen Camasso-Richardson MD, Carolyn Kercsmar MD. University Hospitals of Cleveland and Case Western Reserve University. Cleveland, OH.

BACKGROUND: All children visiting our emergency department (ED) for asthma are treated using an asthma care path (ACP). The ACP is an assessment-driven, algorithm-based treatment regimen. **AIM:** To determine if nebulizer brand utilized in the ED treatment of children with status asthmaticus makes a difference in patient and/or clinical outcomes. **METHODS:** We randomized 280 children, ages of 1 through 7, to receive standardized treatment (3.75 mg of Albuterol) in our ACP with three different nebulizers (Marquest's Acorn, Westmed's Circulaire, and Salter's Nebutech). The ACP standardized assessments and therapy (0_2, albuterol aerosols and corticosteroids) at prescribed intervals (every twenty minutes). Treatment was discontinued when discharge criteria were met: good air exchange, mild or absent end expiratory wheezing, no accessory muscle usage, $Sp0_2 > 93\%$ and respiratory rate < 40/min. After meeting criteria, patients were observed for an hour and discharged home. Patients not meeting discharge criteria after six aerosols or one hour of continuous aerosols were admitted. A chronic asthma severity was assigned based on history, symptoms, and therapeutic drug usage. **RESULTS:** Retrospectively, twenty-one children originally randomized to the study were eliminated from the results for the following reasons: inappropriate age (6), inappropriate diagnosis (7), removed from study by guardian (1), and not receiving at least 1 ED treatment (7) by assessment. Outcomes were analyzed by ANOVA and Chi Square tests ($p < 0.05$) for the 259 children completing the study. A comparison of the predetermined outcomes by means (SD) or percentages are listed in the tables below.

Demographics	**Acorn**	**Circulaire**	**Nebulech**	**p value**
Number	88	86	85	
Age	3.6 ± 1.9	4.2 ± 2.0	4.1 ± 2.3	0.10
Gender (male)	78%	64%	69%	0.09
Non-caucasian	84%	85%	85%	0.97
SpO_2 at presentation (%)	94.7 ± 3.4	94.7 ± 3.4	95.5 ± 3.1	0.14
Respirations @ presentation	44.2 ± 12.8	41.2 ± 12.9	41.2 ± 15.6	0.28
Severe Asthma	34%	36%	34%	0.94
Outcomes				
ED length of stay (hrs)	2.4 ± 0.8	2.5 ± 0.8	2.1 ± 0.8	0.001
Treatment duration (hrs)	2.2 ± 0.8	2.2 ± 0.7	1.8 ± 0.6	0.001
Aerosols given	4.3 ± 1.6	4.1 ± 1.7	3.1 ± 2.0	<0.001
Hospital admits	47%	36%	23%	0.02
ICU admits	3%	6%	4%	0.57

CONCLUSION: In this study, patients treated with the Nebutech nebulizer demonstrated significant decreases in ED length of stay, total treatment times, admission rates and mean number of treatments given compared to the other two devices (Acorn and Circulaire). In our ED study, nebulizer brand utilized to treat pediatric asthma appears to make an impact on both clinical and financial outcomes.

OF-99-045

CARDIAC ASTHMA/STRIDOR-A PRECIPITATING SYMPTOM TO RESPIRATORY FAILURE AFTER CARDIAC SURGERY

D. Orloff, K. Dezoysa, Department of Respiratory Services, Robert Wood Johnson University Hospital, New Brunswick, NJ.

Background: Cardiac asthma is a term used to describe asthma-like symptoms in the presence of severe pulmonary congestion and acute heart failure. The primary characteristics of cardiac asthma are a combination of high pitched inspiratory and/or expiratory wheezing, marked dyspnea, and pronounce inspiratory crackles. Cardiac asthma can also be identified by its response to diuretic therapy and by being refractory to standard treatment of bronchial asthma. Stridor is a harsh, high-pitched wheeze that is characterized as inspiratory, expiratory, or biphasic. It has a frequency of 400 to 800 hertz (normal conversation is around 20 hertz). Methods: It was postulated that stridor was due to one or more of the following: A. traumatic intubation, B. excessive endotracheal tube cuff pressures (>25cm H2O), C. prolonged length of intubation [(LOI) >24 hours post-op)]. Initial treatment of upper airway wheezing (stridor) consisted of albuterol sulfate 2.5mg/3cc NSS via high flow nebulizer (HFN), racemic epinephrine 0.1 to 0.5cc of a 2.25% solution/3cc NSS via HFN, ipratropium bromide 0.5 mg/3cc NSS via HFN, and patient placement in the Fowlers position. Furosemide was added to the treatment plan secondary to the frequency of crackles, which unremarkably reduced the work of breathing. Results: During a four month period, 454 cardiac surgery procedures were completed of which 28 patients developed 33 cases (6%) of upper airway wheezing (stridor) approximately 72 hours post-op. Of the 33 cases, 19 (57%) cases required aggressive treatment and remained on the nursing unit [furosemide 20 to 80 mg IVP was given within 5 minutes of onset of symptoms (and terbutaline 0.25 mg injected subcutaneously in 2 of the 19 cases)]. 5 cases (15%) required reintubation and consequently returned back to the SICU with no diuretic being given prior to intubation. 100% of the stridorous population revealed bilateral crackles upon chest auscultation. Endotracheal tube cuff pressures averaged 17.09 cm H2O, LOI averaged 17.4 hours, and all laryngoscopies were atraumatic (as per anesthesia OR flow sheet). Conclusions: IV furosemide along with aerosolized albuterol sulfate showed the greatest improvement in relief of symptoms over albuterol sulfate, racemic epinephrine, and ipratropium bromide alone. Stridor, by definition, was clinically identified noninvasively in all 33 cases. However, traumatic intubation, prolonged intubation, and exessive endotracheal tube cuff pressures were ruled out.

OF-99-124

The Successful Use of Heliox in an Intubated Patient with Status Asthmaticus

Donna Tripp, RRT; John D. Davies, BS, RRT; Mike Gentile, RRT; J. Chad Davis, MD; Ira M. Cheifetz, MD; Pediatric Critical Care Medicine and Respiratory Care Services; Duke University Medical Center; Durham, North Carolina.

Introduction: The low density property of helium makes it a valuable tool for the treatment of airway obstruction by improving gas mobility around obstructions. This increased mobility has a two fold effect. Gas more readily reaches the alveoli thus allowing for greater gas diffusion. Additionally, the patient work of breathing can be significantly reduced by using a less dense gas. Successful use of helium has been well documented in spontaneously breathing patients; however, its use in conjunction with mechanical ventilation is unclear at present. We would like to present the following case as an illustration of how heliox might be used in conjunction with mechanical ventilation both effectively and safely.

Case Presentation: K.H. is a 13 year old white female with a history of reactive airway disease with no prior history of intubation. She was admitted to our PICU from an outside hospital where she was intubated for respiratory failure. The patient was receiving therapeutic doses of aminophylline, methylprednisolone, ipratropium and continuous albuterol (40 mg/hr). She was sedated and paralyzed. Ventilator management was optimized with the aid of continuous airway graphic monitoring and capnography (CO_2SMO Plus; Novametrix Medical Systems, Inc.). The pt was acidotic and hypercarbic (pH 7.16; $PaCO_2$ 79 mmHg) on admission. The $PaCO_2$ continued to increase. After eight hours the $PaCO_2$ was 89 mmHg. Capnography showed an $ETCO_2$ of 98. A decision was made at that time to initiate heliox therapy (70% helium / 30% FIO_2) in conjunction with mechanical ventilation. The $ETCO_2$ showed an immediate decrease from 98 to 71 mmHg. Arterial blood gas analysis showed a PCO_2 of 67 mmHg, a decrease of 22mmHg, in less than an hour. The patient extubated 30.5 hours later. Heliox and continuous albuterol were continued via face mask for another 96 hours. The patient was discharged from the PICU after seven days and discharged home two days later.

Discussion: Mechanical ventilation of patients with status asthmaticus is challenging at best. Care must taken to assure adequate tidal volume delivery without further overdistention of the alveoli. Additionally, when gas densities are altered, the ventilator may be unable to discern the true tidal volume since many ventilators use pressure gradients to determine volumes. We were able to carefully monitor the delivered tidal volumes using the CO_2SMO Plus, which is configured to compensate flow measurements for specific gas densities. With appropriately monitored delivery, heliox can be a valuable therapeutic modality for the mechanically ventilated patient with airway obstruction.

OF-99-113

ASTHMA MANAGEMENT IN A RURAL ER

Lisa Monchil, RRT, Mark Henderson, MD, Paul Firth, MD, Anthony Ferguson, RRT, Cathy Dirickson, RN, Great Plains Regional Medical Center, Elk City, Oklahoma

The purpose of this study was to improve assessment and management of patients presenting to our ER with an asthma exacerbation. The death of a pediatric patient, during transport to another facility, provided the opportunity for our facility to examine our current practices and identify areas for improvement.

Methods: Using the NHLBI guidelines we targeted two specific outcomes: (1) Reduce the number of return visits to the ER within 72 hours (2) Documentation of patient/ family education. All asthmatic patient charts are reviewed on a concurrent basis for compliance with guidelines and documentation of education and action plans.

Results: Return Visits Within 72 Hours:

1996	**1997**	**1998**
12%	6%	5%
Asthma Admissions through ER		
22%	21%	19%

Development of a patient/family education program significantly improved our efforts in encouraging patient's role in managing their asthma. Intensive staff education in delivering and documenting this education has significantly improved compliance.

Physician use of the guidelines was initially low among our ER staff. Education and results of this study have proven to be successful in changing practice in our ER and in our area primary care practitioners. This has contributed to the success of our program.

Conclusions: Creating a successful asthma management program in a rural ER is a dynamic process requiring input from everyone involved in a patient's care. Our study has expanded from the ER to our inpatients. The success of our program has been an uphill battle but positive results are turning the tide. Future areas to be included are rural health clinics and area schools.

OF-99-183

VALUE OF SCREENING FOR PEDIATRIC ASTHMA RISK IN SCHOOLS.

R.R. Baker, PhD, RRT, RCPT; V.H. Kemp, PhD, FNP; J.A. Lucas, BS, RRT; C.R. Hall, BS, RRT, RPFT; C.B. Arant, BS, RRT; and N.T. Rupp, MD, Medical College of Georgia, Augusta, GA

BACKGROUND: Exercise-induced bronchospasm (EIB) has been associated with the development of symptomatic asthma and chronic impairment of lung function. Parental or child self-report may not adequately identify children at risk for asthma. Our goal was to examine the prevalence of exercise related asthma in an inner city elementary school attended only by African-American children. **METHODS:** We attempted computerized spirometry and a standardized, outdoor free running test in 190 children in grades K through 5 during physical education (PE) classes folowing parental consent. The children were also screened with an 8 question survey prior to testing. Chronic airway obstruction (CAO) was suspected if baseline FEV_1 was < 80% of predicted and the FEV_1/FVC ratio was < 0.80 or FEV_1 increased >10% post-bronchodilator. EIB was identified by a post-exercise fall in FEV_1 of ≥ 10%. Ninety-three percent (176) of the children were able to complete both the pulmonary function and exercise tests. **RESULTS:** The percent of students with EIB and/or CAO are presented by grade in the following table. Thirty-one percent (54 of 176) of the students had either EIB, CAO or both. School records did not identify breathing problems in 80% of students with EIB or CAO. Two questions related to "having asthma" and "wheezing" were significantly correlated (r= 0.75 and 0.90, respectively; p<0.05) with CAO or EIB. **CONCLUSION:** Adequate treatment of asthma requires recognition and diagnosis. This screening procedure identified a significant number of children with respiratory abnormalities and potential breathing problems related to exercise which were not adequately recognized, evaluated, or treated.

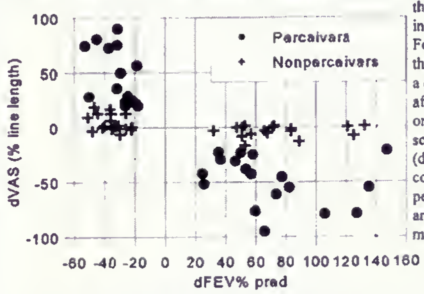
Grade (n)	EIB% (n)	CAO% (n)	EIB + CAO% (n)	Total% (n)
K (26)	7 (2)	7 (2)	4 (1)	19 (5)
1 (25)	16 (4)	4 (1)	4 (1)	24 (6)
2 (28)	21 (6)	7 (2)	7 (2)	36 (10)
3 (35)	17 (6)	14 (5)	9 (3)	40 (14)
4 (32)	22 (7)	13 (4)	6 (2)	41 (13)
5 (30)	3 (1)	13 (4)	3 (1)	20 (6)

OF-99-201

PERCEPTION OF BREATHLESSNESS IN CHILDREN WITH ASTHMA.

R.R. Baker, PhD, RRT, RCPT; Shelley C. Mishoe, PhD, RRT; F.H. Zaitoun, MD; J.A. Lucas, BS, RRT; C.B. Arant, BS, RRT; and N.T. Rupp, MD, Medical College of Georgia, Augusta, GA

BACKGROUND: Optimal asthma management requires accurate assessment of symptom severity. However, patients and their physicians are often unable to correctly estimate the degree of airway obstruction. Poor perception of airway obstruction may compromise self-management and place patients at increased risk for asthma morbidity and mortality. The aims of this study were to evaluate the relationship among indices of lung function and perception of breathlessness in asthmatic children during both bronchoconstriction and bronchodilation and to determine a clinically useful method for identifying those at risk for poor perception of airway obstruction. **METHODS:** The 35 patients (ages 6-16 years) in this study were diagnosed with asthma and enrolled in a larger interventional study. They were predominantly male (22M, 13F) and African- American (23 African-American, 8 Caucasian, 2 Asian). Airway constriction was induced by methacholine inhalation followed by albuterol. Patients marked a 10 cm visual analogue scale (VAS) to indicate their perceived degree of breathlessness prior to and during each stage of the methacholine challenge and 10 minutes after bronchodilation. Three methods for assessing perception of breathlessness were examined: 1) the strength of correlation (r) between perception of breathlessness and airway caliber within subjects, 2) the perception score at a 20% decrease in FEV_1 (VAS20) and 3) the interval of change in perception of breathlessness following acute bronchoconstriction (dVASbc). **RESULTS:** Poor perception of bronchoconstriction was found in 51% (18/35) of the patients based on < 20% increase in VAS (dVASbc). Forty-nine percent (17/35) of the patients failed to perceive a change in breathlessness after bronchodilation based on < 20% decrease in VAS scores post-bronchodilator (dVASbd). There was no correlation between adequate perception of breathlessness and standard spirometric measures (baseline FEV_1 or FEF_{25-75}), airway reactivity (PC20), or patient report of asthma symptoms.



CONCLUSION: We conclude that in this pediatric population, poor perception of asthma symptoms is a significant problem. The majority of the VAS20 scores were in the minimally symptomatic range suggesting a major barrier to appropriate asthma self- management. This study also suggests that a change in VAS scores ≥ 20% of the total scale during either bronchial constriction or dilation may provide a simple index for identifying patients at risk of poor perception of airway obstruction.

OF-99-202

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DEVELOPMENT OF A QUESTIONNAIRE TO IDENTIFY PATIENTS WITH ASTHMA WHOSE BELIEFS AND ATTITUDES MAY PLACE THEM "AT RISK".

George Harris[1], Richard E. Hicks[2]. [1]Health Explorers Pty Ltd, Monbulk, Australia; [2]Pacific Testing and Career Services, Mudgeeraba, Australia.

BACKGROUND: Clinical observations suggest that the beliefs, feelings and attitudes of patients with asthma may affect asthma care and the doctor-patient relationship and hence the degree to which their health is 'at risk'. We have developed a questionnaire - *the Asthma Navigator™* - designed to (i) identify patients beliefs, feelings and attitudes related to their asthma and (ii) classify them into clinically meaningful streams according to their responses. METHOD: Using a 'grounded theory' approach, 70 adults with asthma were interviewed to ascertain beliefs, attitudes and behaviours ('dimensions') related to asthma and its management, information and arguments that supported those beliefs, and factors that influenced changes. Analysis identified four patient 'streams': Stream 1 - individuals who self-treat, rarely visit health professionals, and may lack knowledge of asthma treatment; Stream 2 - individuals whose views threaten adherence with accepted asthma management and put them at risk; Stream 3 - those with 'suboptimal' characteristics, between streams 2 and 4, and with evidence of potential for transition; and Stream 4 - individuals coping maturely and in control of their asthma. A pilot questionnaire to allow for clinical determination of Stream was then developed and, after review by an expert panel and field testing, administered to more than 360 patients with asthma in three Australian cities. RESULTS: Statistical and technical analyses of questionnaire responses confirmed the four streams and allowed consolidation to 96 items assessing 10 relevant dimensions. Factor analysis identified three underlying 'factor-dimensions' dealing with (i) asthma awareness, acceptance and management; (ii) beliefs and knowledge about medication; and (iii) feelings and perceptions about the doctor-patient relationship. Reliability (alpha) coefficients for streams, dimensions and factor-dimensions ranged from 0.62 to 0.94 (mean 0.73), and split-half coefficients from 0.65 to 0.94 (mean 0.73), consistent with figures obtained for well-established questionnaires of personal characteristics. Re-testing of a random sample (n = 184) after 9 months indicated 95% persistence of initial stream classification. CONCLUSIONS: The *Asthma Navigator* is a robust and valid source of information on persistent beliefs, attitudes and behaviours that may be relevant to doctor-patient partnering relationships and ultimately to health outcomes for people with asthma.

OF-99-224

BENEFICIAL EFFECTS OF A BEHAVIOUR CHANGE PROGRAM FOR ADULTS AT RISK BECAUSE OF BELIEFS AND ATTITUDES ABOUT THEIR ASTHMA. George Harris, Health Explorers Pty Ltd, Monbulk, Australia. BACKGROUND: Clinical observations and qualitative research suggest that persistent beliefs, feelings and attitudes of people with asthma may relate to their relationship with a primary care physician. We postulated that a constructive 'partnership' between patient and physician would facilitate a shift in behavioural characteristics - as measured by *Asthma Navigator*™ (AN) questionnaire - from those associated with greater risk to those associated with lesser risk. We designed a program - *Asthma Partnerships*™ (AP) to explore this approach. METHOD: Thirty general medical practitioners (GPs) in each of three Australian cities participated in a 3-hour training session, which focused on qualitative findings about patients attitudes, beliefs and feelings related to asthma and the application to physician-patient communication of techniques that facilitate successful behaviour change. Using insights drawn from qualitative research findings and the AN screening instrument, each GP then enrolled five 'at-risk' patients with asthma into a 'Partnership', in which patient and GP worked through a process of behaviour change. AN 'factor-dimension T' (FDT) scores were used to rate patient beliefs, attitudes, and behaviours at enrolment and exit. RESULTS: Among the first 100 patients (age range 16-76 years, 65% female) who completed Partnerships (average 9 months of 'usual care' contacts), AN FDT scores increased - indicating risk reduction - among those in Stream 1 (p = NS), Stream 2 ($p < 0.001$) and Stream 3 ($p < 0.05$) at entry. This shift correlated with reductions in hospitalisation, non-compliance with preventer medications, frequency of symptoms, nocturnal asthma, and restrictions on lifestyle and activity.

Asthma Navigator factor-dimension T scores in 100 Asthma Partnerships patients

AN FDT score	*n* at entry	*n* at exit	% change	Comment
0 to 54.99	29	15	-48%	Streams 1 & 2
55 to 65.99	40	29	-27%	Stream 3
67 to 100	31	56	81%	Stream 4
60 to 100	49	74	51%	Optimal range

CONCLUSION: Completion of an Asthma Partnership had a statistically significant positive impact on beliefs, attitudes, and behaviours associated with asthma risk in patients with higher risk profiles at entry. This, in turn, correlated with positive changes in clinical measures of asthma risk and asthma control.

OF-99-225

CAN AN EXERCISE/WELLNESS PROGRAM IMPROVE PHYSICAL ENDURANCE AND CONDITIONING IN ADOLESCENTS WITH ASTHMA AND / OR OBESITY.

Marsha Rogers CRTT, Carolyn Kercsmar MD, Jill Goodman LISW, Natalie Walters BA, Robert Chatburn RRT, FAARC, and Timothy R. Myers RRT. University Hospitals of Cleveland. Cleveland, OH.

Background: Asthma is the most common chronic illness of childhood affecting nearly 5 million children in the United States. Urban children are at greatest risk; prevalence of inner-city asthma is twice the national rate (8.6% vs. 4.3%). Asthmetic adolescents often avoid physical activity due to fears of triggering an exacerbation. Inactivity leads to physical deconditioning, as well as obesity and low self-esteem, which in turn can cause asthma to worsen. United States data indicate the percentage of overweight adolescents has more then doubled in the past 25 years from 5% to 11%. **Aim:** To investigate whether a noncompetitive, fitness-wellness program for inner-city adolescents with asthma and / or obesity can result in an increase in exercise tolerance and endurance. **Methods:** Our Respiratory Department in conjunction with Pfizer Inc. sponsored a fitness-wellness program for asthmatic and / or obese adolescents (10-15 years old). Participants met twice weekly after school for 8 weeks. Hospital-based sessions lasted for 60-90 minutes. Each session included three major components: (1) exercise (warm–up, martial arts, aerobics, strength training, flexibility, and cool down), (2) stress management (breathing exercises, relaxation techniques, and mental imagery), and (3) group discussions (peer issues, health issues, medication compliance, improving self-image and self-confidence, etc…). All participants received fitness evaluations at program entry (Session 1) and at program completion (Session 15). Individual fitness evaluations consisted of three areas of measurement. (1) Strength (maximum number of abdominal curls and modified pushups), (2) aerobic fitness (heart rate before and after 3 minute step test using a metronome set at 96 beats/ minute), (3) flexibility (standard sit and reach test), and (4) peak flow (asthmatics only, tested for best peak flow of three attempts). Data were compared with a paired student t-tests at a significance level of $p < 0.05$. **Results:** Ten children completed the fitness-wellness program. All 10 were African Americans. There were 6 females end 4 males. The distribution of participant's chronic conditions was: asthma / weight problems ($n = 2$), asthmatics only ($n = 2$) and weight problems only ($n = 6$). In tha table below, group means (± SD) are compared for conditioning variables measured at program entry and program completion.

Conditioning Variables	Program Entry	Program Completion	p value
Modified push-ups	18.9 (± 11.3)	27.9 (± 15.2)	0.011
Curl-Ups	28.1 (± 17.1)	35.7 (± 14.0)	0.017
Heart Rate Resting	100.3 (± 12.6)	104.0 (± 11.4)	0.584
Heart Rate (3-Min.)	151.2 (± 26.5)	135.3 (± 18.3)	0.114

Conclusion: A noncompetitive, fitness-wellness program for inner-city adolescents with asthma and / or obesity can result in an increase in exercise tolerance and endurance after 16 exercise sections. While not statistically significant, the overall group mean for heart rate post exercise did decrease. Further programs are currently in process to provide a larger study sample for future analysis.

OF-99-231

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THE RELATIONSHIP BETWEEN CRITICAL THINKING PROFICIENCY AND DECISION MAKING SKILL IN PROSPECTIVE RESPIRATORY CARE PRACTITIONERS

Thomas V. Hill, PhD, RRT, Kettering College of Medical Arts, Kettering, OH and A. William Place, PhD, The University of Dayton, Dayton, OH.

BACKGROUND: Respiratory care practitioners (RCP) evaluate the condition of their patients, make decisions about the appropriateness of the treatment plan, provide care, and evaluate the outcomes of their decisions. In order to practice effectively, they must think critically and make appropriate decisions. As educators make curricular changes to improve the decision making skills of their students, strategies to develop critical thinking have been proposed as one method of achieving this goal. This approach is based upon the hypothesis that a positive relationship exists between decision making (DM) and critical thinking (CT). This study examined the relationship between CT and DM in prospective RCP and evaluated differences between educational programs. If a positive relationship could be demonstrated between these constructs, programs may improve the DM skills of future practitioners by providing instruction which improves CT. **METHOD:** Using a correlational research design, DM scores from a clinical simulation examination (CSE) were compared with scores from the Watson-Glaser Critical Thinking Appraisal for 154 graduating respiratory care students from 11 programs. Program directors completed a questionnaire and were then interviewed about the methods they employ to develop CT and DM in their students. **RESULTS:** A significant correlation between CT and DM was found for 110 students completing the Secure Form of the CSE (r = 0.32) and 10 students completing Form 4 of the exam (r = 0.64). No significant difference was found between programs. When examined individually, only 2 programs demonstrated statistically significant correlations between CT and DM. Case studies and clinical simulations were used by all programs, and most utilized role modeling, computer assisted instruction, patient rounds, small group discussion, and study skills courses. No apparent differences were identified in the use of these strategies by different programs. **CONCLUSIONS:** The findings support the prediction that students and practitioners with strong CT proficiency should make better clinical decisions. Assessment of CT proficiency could be used as one part of a process for evaluating prospective students and faculty for respiratory care programs. Program directors and faculty felt that case studies and clinical simulations are important strategies to utilize with their students.

OF-99-013

A COMPARISON BETWEEN RESPIRATORY CARE AND RADIOLOGY STUDENTS' ATTITUDES TOWARD PROFESSIONALISM

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Purpose - The purpose of this pilot study was to investigate the comparison of attitudes toward professionalism between Respiratory Care and Radiology Technology students. The study was designed to determine if there was a significant correlation between students' attitudes from two different disciplines toward professionalism.
Methodology - Surveys of Respiratory Care (RC) and Radiology Technology (RAD) students were conducted at the University of Southern Indiana (Evansville, In.), Northern Kentucky University (Highland Heights, Ky.) and Edison Community College (Ft. Myers, Fla.). The surveys were administered by key instructors (Program Directors or Directors of Clinical Education) in each of the institutions. The students' participation was voluntary with no relationship to any course. The instrument used was an internally (University of Southern Indiana) generated survey addressing ten professional issues: offering expert opinions, patient needs, confidentiality, continual skills improvement, community service, life-long learning, interpersonal skills, personal appearance, and promoting the profession. Each category was assessed using a four point Likert scale (1= Strongly Disagree; 2= Disagree; 3= Agree; 4= Strongly Agree). The data from the returned surveys (N = 136) was entered into the SPSS statistical data base program.
Results - Results from demographic data collected on the group included a mean age of 25.37 ± Std Dev of 7.04; years in college of 3.57 ± Std Dev of 1.71; years in the program 1.69 ± Std Dev of 0.53 and years of work experience of 1.81 ± 4.22. There were 27 males and 109 females completing the survey.
The area having the lowest mean score for both groups was providing community service, 3.06 (± Std Dev of 0.63 for RAD and 3.53 ± Std Dev of 0.50 for RC. There was a significant Pearson r correlation at the 0.01 level (2-tailed) between the two groups in the areas of continual skills improvement, interpersonal skills and promoting the profession.
Discussion - At this level of training, both groups of students seem to be most concerned about obtaining and maintaining skills in their respective disciplines as well as promoting their professions. The area that is obviously of least concern to these students is community service. Professionalism is not just competence but must be viewed on a much broader scale. This is an area that most programs must continually promote and reinforce.

OF-99-072

THE PREPAREDNESS OF ASSOCIATE AND BACHELOR DEGREE RESPIRATORY CARE PROGRAMS TO COMPLY WITH THE AMERICANS WITH DISABILITIES ACT OF 1990 - Linda E Bateman, MS, RRT, Clarian Health Partners, Indianapolis, Indiana - INTRODUCTION: Titles II and III of the Americans with Disabilities Act (ADA) are the primary sections preventing discrimination of persons with disabilities in post secondary institutions A search of the literature indicated information is readily available regarding assisting individuals with disabilities in living skills and job performance. However, little is found regarding assistance in the education of health care students with disabilities. There were two hypotheses for this study: (1) The number of respiratory care students who can be defined as disabled is not significant and (2) The majority of respiratory care programs do not have specific provisions in place to comply with the ADA. METHODOLOGY. A survey was designed to identify demographics of associate and bachelor degree respiratory care programs including the admission of students with disabilities, accommodations to facilitate completion of the educational programs for those students, and policies in place for students with disabilities. The proposed policies were based on suggestions by Essex-Sorlie (1994) for medical schools The survey was mailed to the 290 qualifying programs. RESULTS: One hundred twenty-seven (44%) programs returned the survey. Most respondents were from associate degree programs (81%) and community colleges (67%). Seventy-nine (63%) had knowingly admitted students with disabilities, learning disabilities being the most frequently identified disability. Sixty-three (50%) programs indicated they had provided accommodations for students, listing counselors and tutors most frequently. Ninety-nine (79%) had essential job functions or technical standards either available or in the process of being developed. Oral communication skills were most often required. Only thirty-seven (29%) programs have a standards committee to deal with direct threat issues. Sixteen (13%) stated they did not know if such a committee existed in their institution. CONCLUSIONS: A significant number of respiratory care programs (63%) have admitted students with disabilities. Most programs (94%) have one or more provisions in place to assure compliance with the ADA. Chi Square analysis was done to determine correlations between demographics and having policies in place. Associate degree programs are significantly more likely to have policies for students needing accommodations ($p<0.05$) than bachelor degree programs. Community colleges were significantly more likely to have admitted students with disabilities ($p<0.01$) and have consistent teams for resources when either accommodations are requested ($p<0.05$) or assessment for disabilities are requested ($p<0.05$). Higher numbers of significant correlations exist as to the relationship between having previously admitted students with disabilities and the presence of policies for students with disabilities. The areas of significance in which policies exist are: providing accommodations ($p<0.05$), having a consistent resource team when accommodations were requested ($p<0.05$), having a policy for program applicants requesting accommodations ($p<0.05$), and having training materials on the ADA available to staff ($p<0.01$). No significant correlation exists between class size and the presence of policies for students with disabilities.

OF-99-084

STUDENT PERCEPTIONS OF EDUCATIONAL NEEDS OF A BS PROGRAM IN RESPIRATORY CAER IN TAIWAN

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Introduction: The first formal and school-based respiratory care educational program in Taiwan was developed in 1999. The student perceptions of educational needs of this BS program were not known. In order to understand the educational needs of the incoming student, we performed a survey to all the candidates of the program.
Method: The study population was the applicant of the BS program in respiratory care. The applicant must require an AS degree in allied health profession, a certification in entry level technician training program, and at least two years working experience in respiratory care. A self-designed questionnaire was delivered to the applicant. The questionnaire included the question in applicants' characteristics, the reason why they applied the program, the educational need in the curricula, and the future plan after graduation. The questions in educational needs were rated by a five-point scale. The subject were asked to rate their perceived needs in thirty-five curriculums with 1=strongly unnecessary, 2=unnecessary, 3=no opinion, 4=necessary, 5=strongly necessary. To analyze the data, we used percentages, mean, and standard deviation.
Result: We distributed the questionnaire to sixty applicants and received 43 usable returns (71.7% response rate). The mean age of the subject was 30 ± 5 years old. Forty (93%) respondents were RN in Taiwan and one respondent (2.3%) had passed CRTT examination . The major reasons for applying the program were intent to enhance professional knowledge and ability (n=35, 81.4%),and acquire a higher degree (n=14, 37.8%). Only very few subjects chose expecting to get promotion (n=3, 7%),or finding a better job (n=4, 9.3%) after graduation as the main reason for applying the program. Sixteen curriculums were rated into the two positive response (choosing 4 &5) by more than 90% of the subject which are listed in the Table. Some basic science (i.e. Chemistry, Biology) and non respiratory care related course such as Biomedical statistics, Education, Research, and Health care economics and management were thought less needed by the subject.

Curriculum	Necessary, n(%)
Mechanical ventilation	43 (100%)
Cardiopulmonary pathophysioloy	43 (100%)
Respiratory pharmacology	43 (100%)
Intensive respiratory care	43 (100%)
Fundamental of respiratory care	42 (97.7%)
Cardiopulmonary anatomy & physiology	42 (97.7%)
Respiratory care equipment	42 (97.7%)
PFT	42 (97.7%)

Curriculum	Necessary, n (%)
Cardiopulmonary monitoring	42 (97.7%)
Pediatric/neonatal respiratory care	42 (97.7%)
Pulmonary rehabilitation	42 (97.7%)
Lung mechanics	41 (95.3%)
Long term respiratory care	41 (95.3%)
Computer application	41 (95.3%)
Pathophysiology	39 (90.7%)
ACLS	39 (90.7%)

Conclusion: The BS program in respiratory care can offer a chance to let the RCPs in Taiwan enhance their knowledge and ability as well as acquire a higher degree. Most applicants prefer respiratory care related courses as the necessary curriculum. Although the courses of Education, Research, and Statistics were thought less necessary for the incoming students, we still plan to assign these courses in the program to increase their ability in these fields.

OF-99-086

LUNG AGE ESTIMATION OF SMOKING AND NON-SMOKING COLLEGE STUDENTS 18 - 25 YEARS OF AGE

Sidney R. Schneider, PhD, RRT, RPFT, Robert L. Nichols, BS, RRT, Robert L. Joyner, PhD, RRT, Respiratory Therapy Program, Department of Health Sciences, Salisbury State University, Salisbury, MD 21801

Background: Lung age estimation research arose from a desire to create a positive influence in the education of patients attending smoking cessation programs. Morris et. al. developed reference linear regression equations based on components of forced vital capacity measurements in healthy non-smoking adults, aged 20 to 84 years permitting lung age estimation in terms of pulmonary function[1]. We compared chronologic age and lung age estimates to determine if pulmonary dysfunction associated with smoking is detectable in young adults.
Methods: This study was approved by our institution's Committee on Human Volunteers and informed consent was obtained from every participant. A sample from a population of smoking (n = 5) and non-smoking (n = 9) students 18 - 25 years of age were asked to fill out a questionnaire about their smoking history and undergo pulmonary function testing that included three flow-volume loops. Lung age estimations were calculated by pulmonary function software (Burdick, Inc., Milton, WI) that incorporates linear regression equations developed by Morris et. al[1]. Comparisons were made between chronological age and lung age estimation of smoking and non-smoking students using a two-tailed student t-test (Excel, Redmond, WA). Statistical significance was set at $p \leq 0.05$.
Results: The results (all values Mean ± S.D.) from comparisons showed that non-smokers had no significant difference between chronologic (21.56 ± 1.51 years of age) and estimated (22.89 ± 6.88 years of age) lung age ($p = 0.46$). However, results from smokers showed a significant chronologic (22.8 ± 1.30 years of age) to estimated (37.6 ± 7.30 years of age) lung age difference ($p = 0.01$).
Conclusion: Although this study has a small number of participants, the results indicate lung dysfunction as a result of smoking can be detected in young adults. This lung dysfunction manifests as an increase in estimated lung age. The preliminary findings of this study may be applicable in the educational process of young adults enrolled in smoking cessation programs. Further research in this area should result in a stronger argument for the use of lung age estimation in smoking cessation programs involving teens and young adults.

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OF-99-088

ENHANCEMENT OF ALLIED HEALTH CLINICAL INSTRUCTION USING AN INTERNET CLASSROOM

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SUNY Genesee Community College, Batavia, New York

Abstract

Two allied health programs at Genesee Community College have combined forces to design a structure for clinical training courses (or instruction) using TopClass. The Physical Therapy Assistant and Respiratory Care Programs are using an allied health format so that common needs are addressed and resources and ideas can be "pooled" to enrich the learning experience of all students and minimize redundant tasks between programs. The needs were identified using feedback from students, Clinical Instructors (CI), Center Coordinators for Clinical Education (CCCE), Academic Clinical Coordinators of Education (ACCE), and concerned Administrators. By far the largest area of need identified was communication. Students are matched with CI's from individual health care facilities, placing them remotely from one another, the ACCE, and the college campus. Top class not only enhances the existing lines of communication, but creates new lines of communication that were otherwise impractical or impossible.
Enhanced communication achieves more collaborative communication between the student and ACCE. Self-reflective journal writing in the electronic medium addresses development of interpersonal skills, professionalism, and a method of communicating the student's perceptions of problems and concerns. Also, the students' progress in experiential learning is more closely monitored (and corrected). New areas of communication that the Top Class format allows are communication between individual students, as well as, communication within student groups and communication with experts in specific areas of study or interest.
Additional identified areas of need being addressed are; access to class materials, early intervention by ACCE when problems or concerns occur, students receiving feedback on progression through the course, and students' lack of consistent computer literacy skills.
The program is being run using e-mail and Top Class tools combining personal communication via e-mail with group discussion sections on Tip Class. A pilot course was introduced to the first year students of both programs enrolled in "Clinical Practice I" courses offered summer semester, 1999 at SUNY Genesee Community College.

Additional information can be obtained from the co-authors at:
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OF-99-102

ABSTRACT

Respiratory care educators' preferences for textbooks and instructional aids: A survey. Arthur Jones, EdD, RRT, David C. Shelledy, PhD, RRT, Janet Deguzman, BS, RRT. The University of Texas Health Science Center at San Antonio.
OBJECTIVE: To describe the preferences and uses among RC educators for textbooks and instructional aids. METHODS: We developed and pilot-tested a written questionnaire, in-house. One hundred RC programs were selected by simple random sample. Two questionnaires were mailed to each program (N = 200). Returns were analyzed by spreadsheet. RESULTS: Questionnaires (n = 81) were returned for analysis. Contacts with non-respondents yielded only 3 responses, prohibiting comparison of respondents with non-respondents. The important attributes of textbooks were readability, accuracy and comprehensiveness. The most frequently used aid was the instructor's manual. Computer-based tests were the most useful aid; 35 mm slides were least useful. Computer-based media, videos and case studies are in demand. CONCLUSIONS: Generalization is limited by a 40% response. Authors and publishers should ensure the quality features of a text, e.g., readability, accuracy and organization. Also, they should disseminate computer-based aids. There is a paucity of materials for studies in alternate site care and polysomnography. A future study should survey students about their preferences for instructional aids.

Instructors' perceptions of the usefulness of accompanying materials

	1-Very Useful	2	3	4	5-Useless
Computerized Test Questions	39 (46%)	28 (33%)	12 (14%)	5 (6%)	-
Computerized Presentations	36 (43%)	21 (25%)	15 (18%)	10 (12%)	3 (4%)
Instructor's Manual	34 (40%)	31 (37%)	17 (20%)	1 (1%)	1 (1%)
Hard Copy Test Items	30 (36%)	29 (34%)	19 (23%)	6 (7%)	-
Videotapes	30 (36%)	31 (37%)	18 (21%)	5 (6%)	-
Computer Clip-Art	30 (36%)	18 (21%)	19 (23%)	12 (14%)	5 (6%)
35 mm Slides	17 (20%)	20 (24%)	15 (18%)	18 (21%)	9 (11%)

OF-99-089

INTERDISCIPLINARY PROBLEM-BASED LEARNING

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The rapid pace at which change is occurring within health care has provided a significant and on-going challenge to schools of allied health nationwide. An innovative program emphasizing multidisciplinary education responds to this challenge by preparing next century's practitioners to function within, and develop an appreciation for a team approach to health care. Allied health faculty at the University of Missouri representing the disciplines of Nuclear Medicine, Radiographic Sciences, and Respiratory Therapy created a multidisciplinary problem-based learning course designed to develop students' learning in the areas of cardiac, pulmonary, and vascular emergency care. The problem-based learning format that was employed utilizes small, multidisciplinary groups of students and a series of carefully selected patient cases. The multidisciplinary student teams employ research, critical analysis, and presentation skills to solve a series of problems related to the case. These problems range from airway stabilization skills to imaging interpretation to radiation safety issues. As medical providers seek to control costs while delivering high quality patient care, the multiskilled practitioner will become increasingly important to the practice of medicine. A practitioner who: has an appreciation of other specialties; has worked in a clinical setting with other allied health practitioners; and possesses the skills to perform multiple tasks within the medical setting, is well suited to take a position in medical practice of the next century. The presentation will report how the curriculum was developed, will reflect on implementation challenges, and examine the course outcomes.

OF-99-140

A COMPARISON OF ACADEMIC AND CLINICAL FACULTY RATINGS OF STUDENTS' CRITICAL THINKING AND PROBLEM SOLVING ABILITY TO THE WATSON-GLASER CRITICAL THINKING APPRAISAL AND IN-PROGRAM GPA.

David C. Shelledy, PhD, RRT, Terry S. LeGrand, PhD, RRT, Arthur P. Jones, EdD, RRT, Robert W. Lawson, MS, RRT, and Eric D. Bakow, MA, MPM, RRT, University of Texas Health Science Center at San Antonio, TX.

Purpose: To compare academic and clinical faculty ratings of students' critical thinking and problem solving ability (CTPS) to scores on the Watson-Glaser (WG) and in-program GPA. The CTPS is a 21-item instrument that allows faculty to systematically evaluate students. Scores range from 21 (low) to 147 (high) points. The CTPS has evidence of content validity and has been significantly correlated with WG. Inter-rater reliability has been reported at r = 0.66-0.86 with Chronbach's alpha of 0.95-0.99. The WG is designed to measure ability to reason analytically and logically. Method: Currently enrolled respiratory care students (n = 31) were rated using the CTPS by academic (AF) and clinical faculty (CF). A dependent t-test was used to compare mean AF CTPS and CF CTPS ratings. Pearson product-moment correlations compared CTPS, WG and GPA. Results: Mean (SD) scores were WG: 56.9 (8.6); AF CTPS: 113 (18.8); CF CTPS: 133 (17.8) and GPA: 3.19 (0.81). There was a significant difference between AF CTPS and CF CTPS (t = -4.2; p = 0.0002). Table 1 lists the correlations for CTPS, WG and GPA. There was general agreement in CTPS scores among AF and significant correlations for AF CTPS scores and GPA (r = 0.63; p = 0.001). WG also correlated with GPA (r = 0.37, p = 0.04). There was no relationship between CF CTPS scores and most individual AF CTPS scores, GPA or WG. Conclusions: Academic faculty tended to agree on CTPS ratings and AF CTPS tended to correlate with students' academic performance. Clinical instructors CTPS ratings were significantly higher than AF, were not useful in predicting academic performance and did not correlate well with assessment by academic faculty or with general critical thinking ability.

Table 1. Correlation Matrix for Academic and Clinical Faculty Ratings of Students' Critical Thinking Ability Compared to the Watson-Glaser Critical Thinking Appraisal and In-Program Respiratory Care Grade Point Average (GPA).

	CTPS AF 1	CTPS AF 2	CTPS AF 3	CTPS AF 4	CTPS-CF	In-Program GPA	WG
CTPS AF 1	--	0.47**	0.22	0.44**	-0.02	0.24	0.12
CTPS AF 2	0.47**	--	0.51**	0.49**	0.14	0.66**	0.34
CTPS AF 3	0.22	0.51**	--	0.56**	0.24	0.48**	0.35*
CTPS AF 4	0.44**	0.49**	0.36**	--	0.36*	0.51**	0.12
CTPS AF Avg	0.73**	0.88**	0.69**	0.72**	0.21	0.63**	0.32
CTPS CF	-0.02	0.14	0.24	0.36*	--	0.003	0.03
In-Program GPA	0.24	0.66**	0.48**	0.51**	0.003	--	0.37*

* $p \leq 0.05$
** $p \leq 0.01$

CTPS - Critical Thinking and Problem Solving Scores
WG - Watson-Glaser Critical Thinking Appraisal
AF - Academic Faculty
CF - Clinical Faculty

OF-99-145

USING COMPUTER SIMULATION, CONCEPT MAPPING, AND STUDENT INTERVIEW TO ASSESS CONCEPTUAL DEVELOPMENT AND GAPS IN KNOWLEDGE OF OXYGEN TRANSPORT AND UTILIZATION IN CARDIOPULMONARY PHYSIOLOGY.

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James H. Wandersee, Ph.D., 15 Degree Laboratory, LSU, Baton Rouge, LA.

The purpose of this research was to explore how students and graduates from a BS-level RC education program develop and employ conceptual understanding of oxygen transport and utilization. The study focused on students' conceptual development and the presence of alternative conceptions, prior to, during, and following completion of a course in a cardiopulmonary physiology. Students completed exercises and simulated patient-case studies focusing on cardiopulmonary disease states via a computer simulation program for teaching physiology (SimBioSys, ©1994-1997). Data were examined in reference to: 1) novice group A using the simulation program prior to each formal lecture, 2) novice group B using the simulation program following course completion, and 3) an intermediate group (graduate RCPs) who completed the simulation program following formal respiratory care education. Novice groups completed simulation exercises in cardiopulmonary physiology focusing on oxygen transport and utilization. The intermediates completed patient case studies focusing on "real-life" management and treatment of patients with cardiopulmonary disease. A comparison of the academic achievement of all groups was made, and lines of critical reasoning were examined. Following the study, alternative conceptions, propositional knowledge statements, and gaps in understanding were identified and remediated. Data gathered from student groups included quantitative and qualitative data from student-generated concept maps, test scores, and protocol analysis for pre- and postinstructional interviews (See table). Results suggest that use of computer simulation, concept mapping, and interview may be an effective evaluative triad for assessing conceptual development and diagnosing gaps in knowledge, as well as for identifying alternative conceptions. Analysis of data revealed limited support for use of computer simulation to augment learning concepts of oxygen transport and utilization prior to lecture. It was demonstrated, however, that students' prelecture use of the simulation program helped assess learner knowledge, thus enabling the instructor to select and implement appropriate teaching strategies. Use of computer simulation following formal instruction was shown to be useful in identifying necessary remediation. An important result of the investigation was the delineation of effective instructional strategies leading to meaningful and mindful science learning to improve clinical problem-solving.

	Sample of Data			
	Pretest score (precourse)	Posttest score (post course)	Propositional knowledge statements	Alternative conceptions
Novice A&B	35%	77%	235	119
Intermediates			110	81

OF-99-180

VENTMED: AN INTERACTIVE COMPUTERIZED SIMULATION FOR TEACHING VENTILATOR MANAGEMENT PROTOCOLS

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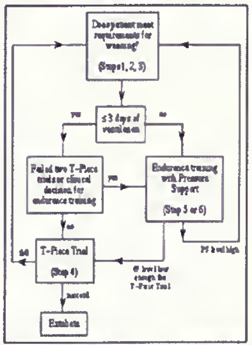
We have developed a computerized simulation of a virtual patient and ventilator (VENTMED), to help train practitioners and other clinicians in our ventilator management protocols. This format allows the clinician to treat a simulated patient rather than receive only a didactic presentation. **Background:** This computerized simulation is a self-contained module that teaches the Jefferson Weaning Protocol [Resp Care 1996;41(10):948]. The protocol, using PSV for endurance muscle training, has traditionally been taught to practitioners using in-services by a staff member who reviews the steps of the protocol. VENTMED assures thorough and consistent content, and allows practitioners to periodically refresh their competency at their individual pace and convenience. **Method:** VENTMED consists of three parts: the course, the patient model, and the ventilator model. The course guides the user through the protocol (shown) and explains each step. The course is linked to the simulation so that material is presented at the appropriate time. The patient model consists of a mathematical model of lung mechanics, gas exchange, and respiratory control. The ventilator model is an adaptation of the Bear 1000 (Thermo Electron). The simulation can be viewed through both the virtual ventilator's monitors and a three-dimensional depiction of the patient and equipment. VENTMED tracks each user's decisions and prepares a performance review at the case conclusion. The program runs on ordinary hospital workstations (Pentium 133MHz; Win 95/98/NT). **Results:** The program has been trialed by practitioners and physicians. A case simulation averaged 20 minutes. Users reported the patient and ventilator simulation made learning the protocol immediate and the visualization and interaction made the training more challenging and enjoyable. Since the program requires no special hardware, it can be used in hospital computer-training centers, on the patient floors, or even at home. **Conclusions:** VENTMED shows promise as a tool for enhancing both teaching of Respiratory Care protocols and competency evaluation.



OF-99-170

PROGRAM RELATED FACTORS ASSOCIATED WITH IMPROVED NATIONAL BOARD EXAMINATION PERFORMANCE.

David C. Shelledy, PhD, RRT, Tracey H. Dehm, BS, RRT, Janet Padilla, BS, RRT. The University of Texas Health Science Center at San Antonio, San Antonio, Texas.

PURPOSE: To determine program related factors associated with improved graduate outcomes, we compared institution, degree awarded, number of faculty, number of affiliates, class size, number of applicants, and attrition rate, to determine if there were relationships between these factors and reported graduate pass rates on the entry level (CRTT), written registry (WRRT) and clinical simulation examinations (CSE). **METHOD:** Data reported on the 1996 accreditation Report of Current Status for all currently accredited respiratory therapist programs (n=300) was provided to the researchers in a blinded fashion so that specific program names and personnel could not be identified. Categorical variables were compared by class performance averaged over a five year period for the CRTT, WRRT and CSE examination expressed as the percentage of the class passing. Correlation coefficients were calculated for predictor variables for CRTT, WRRT and CSE performance. **RESULTS:** Graduate performance by specific program factor was:

	Mean (SD) Scores		
	CRTT % Pass	WRRT % Pass	CSE % Pass
Sponsor			
Technical Institute	93.9 (13.1)	86.3 (12.2)	79.6 (15.8)
Comm. College	96.7 (5.6)	85.6 (12.1)	80.3 (14.3)
Four-Year College	97.6 (4.4)	90.3 (10.1)	87 (12.1)
University	94.2 (14.3)	87.2 (12.8)	81.6 (14.1)
Degree Awarded			
Certificate	85.6 (25.8)	82.7 (16.7)	78.3 (16.98)
Associate	96.9 (5.97)	86.1 (11.7)	80.8 (14.4)
Bachelors	94.5 (12.3)	89.7 (12.5)	83.2 (12.0)
Program Director Credentials			
Associate	97.3 (3.1)	81.7 (18.4)	73.0 (21.9)
Bachelors	95.1 (9.7)	84.8 (12.6)	76.1 (15.7)
Master's	96.3 (7.3)	87.5 (11.8)	83.2 (13.3)
Doctorate	96.9 (6.0)	89.5 (9.5)	84.8 (11.6)

There were no significant relationships between number of clinical affiliates, class size, applicant pool, number of faculty or attrition rate and student performance. As maximum number of students accepted and number of dropouts due to sciences, finances or "other" increased, graduate performance declined significantly. There was also a weak, but significant positive correlation between level of education achieved by key personnel and graduate performance. Job placement also correlated with CRTT (r = .32) and CSE performance (r = .30). **CONCLUSIONS:** Baccalaureate degree program graduates performed better on the WRRT and CSE exams, although associate degree graduates performed better on the CRTT. Programs in which key personnel held a graduate degree tended to out-perform graduates of other programs.

OF-99-194

LETHAL ARRHYTHMIA RECOGNITION AMONG GRADUATING BACCALAUREATE DEGREE RESPIRATORY CARE AND NURSING STUDENTS.

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Purpose: Health care professionals must be able to recognize lethal arrhythmias at the bedside and know the immediate action that will increase the likelihood of a positive outcome. The purpose of this study was to assess the ability of graduating baccalaureate degree respiratory care and nursing students to identify and recommend appropriate treatment of lethal arrhythmias as displayed on an arrhythmia simulator. Method: Respiratory care (RT) and nursing (RN) students enrolled at a university health science center and nearing the end of their respective programs were shown five cardiac rhythms, including normal sinus rhythm, ventricular tachycardia, ventricular fibrillation, asystole, and third degree heart block. Each was asked to identify the rhythms and recommend appropriate action. Arrhythmias were generated by an Armstrong Medical Industries, Inc. AA-820 patient simulator and were displayed on a Biomedical Systems 401 patient monitor. The ability of respiratory care and nursing students to recognize and appropriately treat lethal arrhythmias was assessed with a quiz composed of 10 questions, worth 10 points each, and scores were expressed as a percentage. Scores were reported for rhythm recognition, appropriateness of action to treat the arrhythmia, and total correct responses. Mean scores were compared using an independent t-test with $p < 0.05$ being considered significant. Results: Demographic data and mean scores (SD) are shown in Table 1. Graduating RT's recognized significantly more lethal arrhythmias than graduating RN's, and chose the appropriate corrective action significantly more often than RN students. As expected from these results, total points scored by RT students were significantly higher than those scored by RN students. Conclusions: Respiratory therapists and nurses treat patients who are at risk for development of lethal arrhythmias. The results of this study suggest that respiratory therapy students are better prepared to identify and recommend appropriate treatment of common arrhythmias encountered in the clinical setting, when compared with nursing students. The results are not surprising since respiratory therapy students undergo rigorous instruction in cardiac and pulmonary pathophysiology. In today's changing health care environment, clinicians who possess excellent bedside assessment skills and the knowledge to act quickly and appropriately in the face of a crisis are valuable members of the health care team and will contribute to improved patient outcomes.

Table 1. Scores for lethal arrhythmia recognition and knowledge of appropriate action to be taken for graduating nursing and respiratory care students.

	RT	RN	t	p
N	16	16	--	--
Age, yr.	26.9(4.0)	29.4(8.8)	-1.02	0.316
Experience, yr.	0.95(2.5)	1.17(2.6)	-0.25	0.804
Education, yr.	4(0)	4(0)	--	--
ID score, %	92.5(10.0)	80(18.1)	2.44	0.02*
TX score, %	61.3(13.6)	43.3(15.7)	3.53	0.001**
Total score, %	76.9(10.1)	61.7(14.7)	3.47	0.002**

* $p < 0.05$ ID score - score for arrhythmia recognition

** $p < 0.01$ TX score - score for appropriate action recommended

OF-99-200

INTERNET AND COMPUTER APPLICATION BEFORE AND AFTER AN INTERNET-BASED COURSE IN A BACCALAUREATE RESPIRATORY CARE PROGRAM

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Background: A one-semester credit Internet-based course, Current Topics I, was developed and offered to senior baccalaureate level students during the fall, 1996 semester. WEB-CT, an Internet course template, was used to develop the course. Among the goals of the course were to 1.) increase student experience in the use of the Internet as an information resource and 2.) improve student proficiency with computer applications.

Method: The course consisted of eight current topics. Students searched the Internet for references that served as the basis for an Internet-based, asynchronous, threaded discussion of each topic. A pre-course survey was administered prior to participation in the course and the identical survey was administered during the spring, 1999 semester. The survey elicited quantitative and qualitative data concerning the student's current experience and perceived proficiency in the use of the Internet and in basic computer applications.

Results:

Student Responses	Pre-course	Post-course
Proficient with computer applications	20%	60%
Regularly use e-mail	30%	100%
Regularly use the Internet	50%	100%
Concern for computer-related deficiencies	50%	0%

Experience: This course was the authors' first experience with Internet-based education. Internet-supported (e-mail, forum, course evaluation and testing) capabilities have subsequently been added to several courses in the curriculum. Additionally, the program is developing a non-traditional CRT-to-RRT and a RRT-to-BS track, each of which contain a significant Internet-based course component. Program faculty is also discussing the feasibility of problem-based learning utilizing an Internet-based course.

Conclusions: This data suggests that an Internet-based course may be associated with increased use and improved proficiency in Internet and computer applications that is maintained after completion of the course. Professional educational programs might anticipate that Internet-based courses could be successfully implemented despite initial student computer-related deficiencies.

OF-99-204

SIMULATION OF CLOSED CHEST COMPRESSION ON MECHANICAL TEST LUNG

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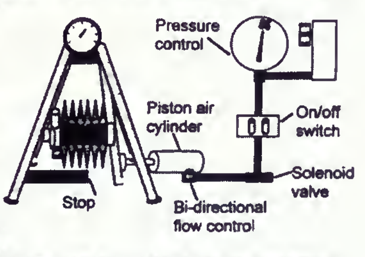
BACKGROUND: Closed-chest compression during cardiopulmonary resuscitation (CPR) is an important lifesaving procedure.[1] Breathing assistance devices, such as manual bag-valve and automatic resuscitators, are pressure sensitive, and their function is affected by chest compression. As breathing assistance devices evolve, the need exists to test these devices, techniques, and equipment to ensure their safety and efficacy. Such a system is described below.

EQUIPMENT: The lung environment was simulated by a commercially available lung simulator (SMS, England MS0015001). An external compression simulator was attached to its structure as well as a pressure tap for data acquisition. The simulator was equipped with controls to regulate cycle rate, speed, force, and distance. The lung compression device was comprised of an air cylinder with bi-directional flow adjustments to control compression speed, a pressure adjustable air supply to control maximum force, and control circuits and a solenoid valve for actuation. The cylinder mount directed the cylinder rod against the mechanical test lung and a stop was mounted to the frame to simulate the maximum depth of an external compression. A fine adjustment scale on the speed and pressure control was essential to ensure repeatability.



METHODS: A breathing device, such as a manual bag-valve or automatic resuscitator, was used to simulate inhalation and exhalation functions. The chest compression simulator was cycled to simulate CPR. This was helpful in evaluating synchronous and non-synchronous compressions with breathing cycles at various compression rates.

RESULTS: The compression rate was set at 80 times per minute with a ratio of 5 compressions per breath. The proximal airway pressure waveform was recorded utilizing a computer data acquisition system. The pressure waveform represented external chest compressions during resuscitation.

CONCLUSION: Because this lung compression system is so versatile, it can be used to evaluate many different types of respiratory devices. In this case, closed chest compressions were simulated under controlled conditions. This system can be effectively used to test the safety and efficacy of other breathing assistance devices.

Supported by VORTRAN Medical Technology 1, Inc.

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1. National Conference on Cardiopulmonary Resuscitation and Emergency Cardiac Care. Standards and guidelines for cardiopulmonary resuscitation (CPR) and Emergency Cardiac Care (ECC). JAMA 1986;255(21):2905-2984.

OF-99-214

EMERGENCY AIRWAY MANAGEMENT COMPETENCY FOR RESPIRATORY THERAPISTS,

John D. Hussey MBA, RRT, Lewis Massey, S. Lakshminarayan MD, Piotr Michalowski MD, PhD, Michael J. Bishop, MD, Veterans Affairs Puget Sound Healthcare system, Seattle, Washington.

At our medical center we successfully implemented a two-tiered response for emergency airway management by respiratory therapists and anesthesiologists. As part of the program, yearly recertification to maintain the skill is required. Following the first year of the program, each therapist was asked to return to the operating room (OR) and demonstrate competency in airway management. In order to optimize the recertification process, we conducted a prospective study at the end of the first year of the program to determine which variables correlated with the intubation success rate during the recertification period. The therapists (N=12) took a 21-question written test prior to return to the OR for skills assessment and anesthesia supervised intubation. The test included questions about pre-intubation assessment, anatomy, appropriate use of laryngoscope blades and the step-by-step process of the procedure. Following written testing, each therapist performed a series of intubations. At each attempt, one of two RT supervisors assessed whether the following elements of the procedure were performed correctly: airway assessment, equipment check, mask ventilation, laryngoscope placement (patient mouth opening and tongue displacement), blade pulled rather than levered on the teeth, and tube placement with the tip of the tube coming in from the right side. The frequency of the correct task performance and the first pass success rate was noted. Therapists were recertified by the anesthesiologist when all of the elements on the checklist were routinely performed, although a minimum of five was required of all therapists.

RESULTS

1. There was no correlation between the number of emergency intubations performed during the prior year by the therapist and the number of intubations required to be recertified.
2. There was a negative correlation ($r= -0.8$)($p<0.05$) between a score on the written test and the number of intubations required for recertification (better test scores required fewer intubations).
3. Successful intubation on the first attempt occurred more frequently when all elements of the procedure were performed correctly (67% vs 36%, $p<0.01$).
4. The most common errors were not attempting to insert the tube from the right side of the mouth (27%) and levering the blade on upper teeth (13%). When the blade was levered, 80% of first attempts at intubation failed.

CONCLUSION

A good knowledge of the anatomy and procedure (as demonstrated on a written exam) is an important predictor of successful first pass intubations and overall competency in the airway management. Emphasis on teaching the proper use of the laryngoscope blade and insertion of the endotracheal tube from the right side of the mouth may be useful since this improves first attempt success rate. The number of emergency intubations in the preceding year is not a good predictor of skill maintenance, presumably because bad habits are not always corrected.

OF-99-233

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THE EFFECT OF TUBING LENGTH, GAS FLOW, AND NUMBER OF HEATERS ON MAXIMUM GAS TEMPERATURE FOR AEROSOL CIRCUIT USED FOR COLD WATER NEAR-DROWNING OR HYPOTHERMIA

Wayne Wallace, B.A., R.R.T., R.C.P., Coordinator of Clinical Studies, Barlow Respiratory Research Center, Los Angeles and Laurie LaBree, M.S., Statistician, University of Southern California, Los Angeles

ABSTRACT:

BACKGROUND: Clinicians who treat patients suffering from cold water near-drowning or hypothermia routinely warm inspire gases greater than body temperature in accordance with care guidelines promulgated by the various organizations. However, humidifiers are designed to prevent heating gases beyond 41°C (assuming the use of a standard six foot aerosol circuit) in order to meet International Standards Organization regulations (ISO). Clinicians must modify equipment in order to deliver care. There are several factors, which can effect the highest temperature that a particular circuit will achieve. Among the factors that are considered most important for maximum circuit are tubing length, gas flow, and the number of heaters (heat source). METHODS: The maximum temperature that a circuit could achieve was measured after varying tubing lengths (1.5 feet, 3 feet, and 6 feet), gas flow (opening or closing a venturi receiving a fixed flow rate of 10 L/min), and the size of the heat source (one or two heated humidifiers in aerosol circuit). A total of ten runs were made in each of the possible twelve combinations. RESULTS: Univariate statistics showed significant differences for Venturi open/close ($p=.0001$) and the number of heaters ($p=.0001$) but not the tubing length ($p=0.19$). However, the multivariate analysis revealed significance for tubing length, number of heaters, and venturi open/closed ($p=.01$). CONCLUSION: All factors (tubing length, number of heaters, and tubing length) were important determinants of maximum gas temperature. The effect of tubing length can be overwhelmed by higher gas flows.

OF-99-004

THE EFFECT OF HIGH DOSE BRONCHODILATORS VIA MDI/SPACER ON HEART RATE

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OBJECTIVE: Manufacturer's guidelines and recommendations have cautioned the use of high dose bronchodilators via Metered Dose Inhaler (MDI). At UCSD Medical Center, the Patient Driven Protocol for Bronchodilator Administration incorporates the titration of MDI dose with a range of 2-20 puffs based on the severity of the patients illness and response to therapy. This dosing regimen permits a larger number of high dose therapies. Our objective was to determine if there was a significant increase heart rate with high dose bronchodilator administration. METHOD: We collected Data on 43 adult patients who received 16-20 puff of Albuterol or Combivent from 10/98 to 2/99. There was no exclusion of patients due to diagnosis or severity in disease process. Bronchodilator dose and pre/post heart rate was tracked as well as any adverse reaction. Significant increase heart rate was defined as a change of 20 BPM or greater. RESULTS: The total number of MDI treatments administered was 333 with an average dose of 17.34 puffs per treatment. Only 1 patient demonstrated a heart rate increase of 20 or greater. This patient received a total of 47 treatments with 20 puffs.Treatment number 27 and 28 had an increase heart rate of 20 BPM and 29 BPM prospectively. Of the 333 treatments the mean heart rate before treatment was 100.16 with a mean of 102.67 after treatment.The mean change in heart rate before and after treatment was 2.4 BPM.
CONCLUSION: Our data indicates that high bronchodilator doses of 16-20 puffs have no significant side effect on patient heart rate.

OF-99-011

EFFICACY OF DOSIMETER-CONTROLLED SMALL VOLUME NEBULIZER BRONCHODILATOR THERAPY IN HOSPITALIZED ADULT PATIENTS. Charles R Hall, Sr. BS, RRT, RPFT, R. Randall Baker, PhD, RRT, RCPT. Medical College of Georgia, Augusta, GA. **BACKGROUND:** Hospitals have attempted to use self-administered MDI as the primary method for bronchodilator delivery due to decreased labor costs. However, use of an MDI to achieve bronchodilation requires proper technique, which is frequently inadequate even after instruction, or a spacer device. Often patients receive little or no follow-up instruction or fail to use a spacer device. Therefore, while hospitals may be saving money, patient treatments may be ineffective. **METHODS:** This study used a crossover design to examine the efficacy of bronchodilation comparing two methods of drug delivery: self-administered MDI without a spacer (saMDI) and dosimeter-controlled small volume nebulizer (dcSVN). In the dcSVN method, a computerized dosimeter controlled the delivery of precise doses of albuterol via a characterized small volume nebulizer (DeVilbiss 646, Pulmonary Data Services, Inc) driven by air at 30 psig. Twelve patients with a current physician order for albuterol were randomly assigned to receive bronchodilator therapy with either saMDI or dcSVN on Day 1 of the study. Subjects received the alternate method on Day 2 within two hours of the treatment time from Day 1. No therapy was given if subjects received a bronchodilator treatment within six hours of study treatment. Baseline spirometry was performed prior to treatment on Day 1 and Day 2. Subjects initially received 180 μg of albuterol via either dcSVN or saMDI. Spirometry was performed 15 minutes later to assess bronchodilator response. Then, a second 180 μg dose was given and spirometry was performed after 15 minutes. No adverse sequelae were noted in any treatment method. **RESULTS:** Eight of the 12 subjects (67%) responded to the bronchodilator as determined by post-bronchodilator increases of both $\geq$ 10% and $\geq$ 0.20 L in either FVC or FEV_1. Spirometry data from the responder group were analyzed using a multivariate analysis of covariance. There was no statistical difference in baseline FVC and FEV_1 values between Day 1 and Day 2. Differences in percent change from baseline in FVC (ΔFVCinit) and FEV_1 (ΔFEV_1init), absolute volume change in FVC (ΔFVC[L]) and FEV_1 (ΔFEV_1[L]), and percentage change from predicted FEV_1 (ΔFEV_1pred) were evaluated as outcomes for bronchodilation in saMDI and dcSVN. Bronchodilator response was significantly greater ($p < 0.05$) for dcSVN when compared to saMDI in each of the spirometric outcome measures. **CONCLUSIONS:** This study demonstrates that dcSVN therapy resulted in greater bronchodilation than saMDI using comparable doses of albuterol. Thus, dosimeter-controlled SVN therapy may improve patient care by providing more effective bronchodilator therapy than self-administered MDI without spacer.

(n=8)		ΔFVCinit	ΔFVC[L]	ΔFEV_1init	ΔFEV_1[L]	ΔFEV_1pred
saMDI	**180 μg**	1.6 ± 2.4	0.07 ± 0.07	4.7 ± 3.2	0.06 ± 0.06	1.7 ± 1.7
	360 μg	2.7 ± 3.2	0.09 ± 0.09	4.9 ± 3.4	0.08 ± 0.07	1.8 ± 2.0
dcSVN	**180 μg**	11.6 ± 4.4	0.29 ± 0.02	12.3 ± 2.8	0.19 ± 0.03	5.2 ± 1.0
	360 μg	15.9 ± 4.4	0.40 ± 0.13	14.6 ± 1.4	0.25 ± 0.03	7.1 ± 0.9

n, number of responders; Values expressed as $\bar{x} \pm$ SE

OF-99-037

HELIOX AS A THERAPEUTIC TOOL IN THE MANAGEMENT OF RSV BRONCHIOLITIS : A PEDIATRIC CASE REPORT.

Melissa K. Brown RRT, Susan E. Duthie M.D. Department of Critical Care, Children's Hospital and Health Center, San Diego, California.

Introduction: Respiratory Syncytial Virus (RSV) is the leading cause of lower respiratory tract infection in infants and children. Annually, tens of thousands of children are hospitalized. Signs and symptoms of RSV bronchiolitis include wheezing, hyperinflation of the lung, dyspnea, retractions, atelectasis, and mucous plugging with resultant increased work of breathing. Of those children hospitalized, approximately 5% require mechanical ventilation. Breathing a helium-oxygen mixture, due to the low-density of the gas, decreases airway resistance and work of breathing. This case study examines the benefit of adding a 60% helium-40% oxygen (Heliox) mixture to the ventilator circuit of a patient with RSV bronchiolitis. Case Summary: The patient is a 3 month 23 day old, 2.8 kg, 28 week gestation, twin, who was at home with the diagnosis of bronchopulmonary dysplasia. She was on Aminophylline and a monitor for apnea at the time of this illness. She presented to an outlying Emergency Department with apnea and required intubation. She was then transported to the CHSD PICU. Upon admission she was placed on a GALILEO ventilator (Hamilton Medical, inc.) with the ventilator settings P-SIMV, PIP of 39 cmH_2O, PEEP of 5 cmH_2O, respiratory rate (r) of 25 , inspiratory time (IT) of 0.8 seconds, 50% oxygen. The Venous Blood Gas on these settings was pH= 7.24, CO_2=54, BE= -4.5, oxygen saturation 100%. The patient's CO_2 increased during the evening and Heliox therapy was initiated. The infant's ventilation improved dramatically on the addition of Heliox, with no change in ventilator settings or other therapies. Her oxygen saturation remained 100%. The following chart summarizes the blood gases pre and post Heliox therapy.

Venous Blood Gas	pH	PCO_2	BE	O_2 Saturation
P-SIMV, 38/5, r.30, 0.7 IT. 50% Oxygen	7.16	92	+4	100%
P-SIMV, 38/5, r.30, 0.7 IT. Heliox	7.35	53	+2.5	100%

Discussion: Heliox dramatically improved the ventilation of this intubated infant with RSV bronchiolitis with no change in ventilator settings. The benefits of Heliox mixtures for patients with asthma and airway obstruction are well documented. There is evidence that Heliox improves the overall respiratory status of children with RSV lower respiratory tract infection. More research is required to determine which patients with RSV bronchiolitis will benefit from this treatment.

OF-99-046

EVALUATION OF MISTY OX GIN BABY™FOR DELIVERY OF CONTINUOUS ALBUTEROL Jessica Potterton, BS, RRT, P/P Spec., Dorisanne Miller, AS, RRT, Theresa Ryan Schultz, BA, RRT, CPFT, P/P Spec., Lorraine F. Hough, MEd, RRT, CPFT, P/P Spec., Linda A. Napoli, BS, RRT, RPFT, P/P Spec., The Children's Hospital of Philadelphia, Philadelphia, PA

Background: Our pediatric institution treats over 3,000 asthma exacerbations each year. The National Institute of Health's guidelines for the treatment of status asthmaticus include the use of continuous nebulized beta agonists. Approximately 760 patients were treated with continuous albuterol sulfate each year. Currently the Heart™ nebulizer, in tandem with a blended high flow aerosol delivery system, is used to insure medication administration with adequate inspiratory flow rate and adjustable FiO_2. We assessed the Misty Ox GIN Baby™ while searching for an alternative cost-effective system that would similarly deliver adequate flows with adjustable FiO_2. Methods: Since hourly output is strongly influenced by nebulizer volume fill and flow rate, we set up the GIN Baby™ system with a volume of 120cc, nebulizing at the total flow rate of 25 lpm. The solution was nebulized for a duration of one, two, and four hours to evaluate the total output in cc/hr. Combinations of jet and injected flow were used to achieve desired FiO_2 with this system. For this reason, we evaluated all combinations of flow rates to achieve total flow rate of 25 lpm. This flow rate delivers adequate inspiratory flows at the widest range of FiO_2 to meet most patient demands. At the conclusion of each set time, the remaining solution was measured with a calibrated syringe, and the output was determined. The final hourly output values were averaged to obtain the total output in cc/hr. Experience: Nebulized output of the solution at a standard total flow rate, over four hours, generated a reproducible average output of 30cc/hr.

Results:

System	Jet Flow (lpm)	Injected Flow (lpm)	Total Nebulizer Flow (lpm)	Average Nebulizer Output (cc/hr)	Estimated Annual Disposable Set-up Cost
Misty Ox GIN Baby™	5 10	20 15	25 25	26 30	$4,053.84
Heart"™ Nebulizer System	N/A	N/A	10	30	$32,156.40

Conclusion: Continuous aerosolized albuterol sulfate may be administered through the Misty Ox GIN Baby™ with comparable output to the Heart™ nebulizer with a higher flow rate to meet patients' demand. Additionally, this method provides a cost savings of $36.88 per set up, with an estimated annual saving of $28,102.56. These findings justify a hospital wide evaluation of this product including a potential time savings analysis.

OF-99-050

THE EFFECT OF POSITIVE EXPIRATORY PRESSURE (PEP) ON AEROSOLIZED ALBUTEROL DELIVERY. J. L. Rau, Ph.D., RRT, Georgia State University, Atlanta, GA.

The combination of positive expiratory pressure (PEP) with inhalation of aerosolized albuterol may improve lung delivery. **Purpose:** The purpose of the study is to determine the effect of PEP on delivery of albuterol by metered dose inhaler (MDI) with either a chlorofluorocarbon (CFC) or hydrofluoroalkane (HFA) propellant. **Methods:** MDI delivery of CFC albuterol (Proventil®) and HFA albuterol (Proventil® HFA) was assessed with an Aerosol Cloud Enhancer (ACE, DHD) reservoir, with and without a PEP device (TheraPEP, DHD) attached. Drug delivery was assessed using an Anderson 8 stage particle size impactor operated at 28.3 Lpm (± 0.5). Aerosol delivery systems were attached to the USP throat for impaction testing. The PEP device was inserted between the reverse-firing ACE and the USP induction throat. Drug collected on impactor plates was analyzed spectrophotometrically at 276 nm, and the fine particle fraction determined as the mass of drug ≤ 4.7 µm. Amounts of drug were predicted from sample absorbances using previously fitted linear regression equations for the base (CFC albuterol) and sulfate (HFA albuterol) respectively. **Results:** Total drug mass, fine particle fractions (% fine), and mass median aerodynamic diameters (MMAD, µm) are reported for each delivery system. Means (and standard deviations) are given. HFA albuterol sulfate is reported as the sulfate, with 120 µg of the sulfate equivalent to 100 µg of albuterol base.

	CFC-ACE	CFC-ACE/PEP	HFA-ACE	HFA-ACE/PEP
Total Mass:	44.4 (7.7)	50.1 (6.4)	50.0 (5.1)	58.7 (9.7)
% Fine:	76.4 (9.9)	78.0 (19.9)	84.6 (8.9)	90.5 (2.4)
MMAD,µm	1.3 (0.5)	1.6 (0.8)	1.4 (0.3)	1.3 (0.1)

There was no significant difference in delivery between the MDI/ACE alone, and with the PEP device attached (Wilcoxon signed ranks test, $p > 0.05$), for either CFC or HFA albuterol. **Conclusion:** The use of the TheraPEP device does not reduce either the total or respirable dose or the MMAD of MDI albuterol with either CFC or HFA propellants.

OF-99-080

BRONCHIOLITIS: A MODEL OF CARE DELIVERY. Theresa Ryan Schultz, BA, RRT, CPFT, P/P Spec, Ann Marie Wallack, AS, RRT, P/P Spec., Linda Allen Napoli, BS, RRT, RPFT, P/P Spec. The Children's Hospital of Philadelphia, Philadelphia, PA

Background: Traditionally, bronchiolitis management of patients admitted to our institution began with a physician order to deliver nebulized medication and chest physiotherapy at a frequency. Respiratory care administered nebulized therapy and monitored its effectiveness. The remainder of patient monitoring and delivery of chest physiotherapy was done by nursing. Bronchiolitis season has always been a busy time, where up to five therapists per eight-hour shift, each administered as many as thirty-five nebulizer treatments, in addition to meeting all other respiratory needs of these non-intensive care patients. This left little to no time for close observation or evaluation of appropriateness of care. Stoller has established a method to enhance appropriate prescription of respiratory care services as the main impetus for respiratory protocols.[1] **Methods:** A multidisciplinary team within our institution developed protocols to manage bronchiolitis. The goal of these protocols was to minimize misallocation of respiratory care services. These protocols included a system of evaluating and appropriating all therapies ordered for the patient admitted with bronchiolitis, including ventolin, racemic epinephrine, oxygen, chest physiotherapy and nasopharyngeal (NP) suction as needed. Only those therapies yielding positive responsiveness were used in the continuum of care. Implementation of protocols were expanded to include not only a care plan based on severity of illness and responsiveness to therapies, but also a revised model of care delivery. Competency-based cross training for all practitioners was done prior to the start-up of this program. The physician orders "begin bronchiolitis pathway". This initiates a Respiratory Care assessment of the patient and evaluation of therapies outlined in the protocol. This included ventolin treatment (dose by weight) Q1 hr. x 2, followed-by racemic epinephrine (dose by weight) Q1 hr. x 2. NP suctioning, oxygen therapy and chest physiotherapy was administered and evaluated as well. Given the results of this protocolized respiratory evaluation, the patient ultimately received all indicated therapies Q2 hr. when assessed as severe, Q4 hr. when assessed as moderate and Q6 hr. when assessed as mild. The care delivery model was then agreed upon. Patients assessed and treated as severe were managed by respiratory care. Mild and moderate pathway patients were managed by nursing. Patients moved within the pathway based on established guidelines for a child assessed as mild, moderate or severe. Results: The initial assessment and care of these patients was clearly escalated for Respiratory Care Practitiooers.

	Total # tx.	by RN	by RRT
December 11-31	4171	2162 (52%)	2009 (48%)
January 1-31	6929	3477 (50%)	3452 (50%)
February 1-28	6827	2770 (41%)	4057 (59%)
March 1-6	1335	671 (50%)	664 (50%)

The number of practitioners needed to execute this level of care never called for an increase in full-time employees, Respiratory Care or Nursing. This was made possible only because the model of care also changed, leaving the respective discipline responsible for the care of the patient, to provide comprehensive care. Coordination of the care provided was elicited subjectively as a positive outcome among staff therapists and nurses. Conclusions: The implementation of the bronchiolitis protocol/pathway seemed to enable appropriateness of care without increasing the number of care providers for the bronchiolitis population. Financial analysis of the program will give further insight to this pilot program.

1. Stoller JK. The Rationale for Therapist-Driven Protocols: An Update. Respiratory Care 1998; 2(1):1-14.

OF-99-051

LEVALBUTEROL HCL (LEV) IS COMPATIBLE WITH IPRATROPIUM BROMIDE (IB) AND CROMOLYN SODIUM (CS): RESULTS OF A MIXING STUDY. MaryAnn Murphy, RPh, Walter Piskorski, (Charles Eck, PhD. Sepracor, Inc., Marlborough, MA; (Primedica Corp, Cambridge, MA. Background: Frequently, asthma patients or caregivers administer several medications by co-mixing the products in the nebulizer, despite labeling indicating that there is no data to support this practice. This study was conducted to determine if LEV is compatible when mixed with IP (Atrovent Inhalation Solution) or CS (Intal Inhalation Solution) and if mixing alters the chemical composition of the products. Method: Control samples were prepared, and the concentration of each analyte was determined by diluting and analyzing each individually. Analytes were quantified against standard calibration curves using duplicate injections. Recoveries for the three analytes were 112.9% for LEV, 103% for IP, and 116.2% for CS. Afterwards, one 0.63 mg/3 mL vial of LEV was mixed with one 0.02%/2.5 mL vial of IP or one 20 mg/2 mL ampule of CS. For each combination, six samples of solutions were prepared and stored separately. The first mixture was diluted for analysis immediately after mixing; the other samples were analyzed after being stored at room temperature for 1, 2, 3, 4, and 7 hours (8 hour time point for LEV/CS). Results: Recoveries for the LEV/IP mixture ranged from 100-102.1% of the LEV control amount and 99.5-104.9% of the IP control amount (Table). Similar findings were noted for the LEV/CS mixture, with LEV recoveries ranging from 97.7-102.8% of control, and CS recoveries of 103-104.9% of control. For both mixtures, no changes in physical appearance were noted, neither chemical mixture was adversely affected by the process of mixing, and the assay content did not change over time. Conclusion: Levalbuterol HCl is compatible with ipratropium bromide or cromolyn sodium inhalation solution formulations when mixed, and the chemical products are not adversely affected by mixing at the time of mixing or for 78 hours after mixing.

Sample time	Lev % control*	IP % control	CS % control
Control[γ]	112.9	103	116.2
Immediate	102.1; 102.8	102.9	103.1
1 hr	101.3; 99.7	103.9	104.9
2 hr	101; 100.8	100	104.5
3 hr	100; 102	104.9	103
4 hr	101.5; 97.7	99.5	104.2
7/8 hr	100.6; 101.1	102.4	104.2

*Lev recovered in IP mixture; Lev recovered in CS mixture

[γ] Percent control is % label claim

OF-99-103

EFFECT OF NEBULIZER DESIGN ON FINE PARTICLE MASS.

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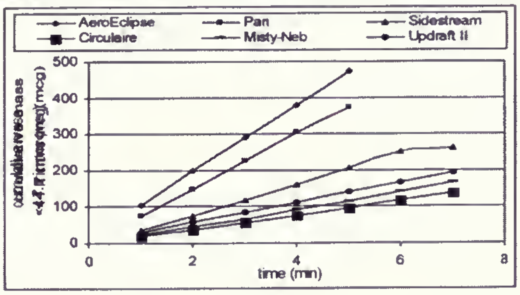
Background: Nebulizer design is known to affect performance. In this study, we compared fine particle mass from nebulizers of four designs. **Methods:** We tested traditional disposable nebulizers (Baxter Misty-Neb™, Hudson Updraft-II Neb-U-Mist®), breath-enhanced nebulizers (Pari-LC-D™), nebulizers with collection bags (Westmed Circulaire™), and a Trudell AeroEclipse™ (with breath actuation disabled). Five of each device with three replicates (n = 15) were tested using an in-vitro model of spontaneous breathing. A rigid bar was placed between the two compartments of a test lung (Michigan Instruments TTL). The drive lung was attached to a ventilator (Infrasonics Infant Star®) to simulate spontaneous breathing (tidal volume 0.6 L, rate 10/min, T_I 2 s). A bacterial/viral filter (Trudell MT3000) was placed between the nebulizer and slave lung. Flow was monitored between the test lung and filter (Novametrix Ventcheck®). Albuterol solution (0.625 mg/mL) was placed into the nebulizers (4 mL), which were powered with air (8 L/min). Filters were replaced at one minute intervals (flow to the nebulizer was discontinued during filter replacement) until sputtering occurred. The filter was washed with methanol (20 mL) and albuterol concentration was measured with HPLC-UV spectrophotometry. Particle size was measured using a Malvern Mastersizer. Fine particle mass was calculated as the product of mass % <4.7 µm and total nebulizer output. **Results:** Fine particle mass from the AeroEclipse™ nebulizer was greater than that from the other nebulizers (P<0.001) (see figure). **Conclusions:** Fine particle mass was affected by nebulizer design. The clinical relevance of this finding awaits further investigation. Further evaluation of the breath-actuated feature of the AeroEclipse™ is warranted.



OF-99-121

INEFFECTIVE DELIVERY OF AEROSOLIZED SALBUTAMOL SULPHATE WHEN GIVEN IN-LINE WITH HIGH FLOW OXYGEN.

Kelly Glanville, BSc, RRT; Kelly Jager, RRT; and J.J. Ronco, MD. Vancouver General Hospital, Vancouver, BC, Canada.

Background: Bronchodilators are commonly administered through small volume nebulizers (SVN) placed in-line with a high flow oxygen source. It is unknown how efficient SVN therapy is when given in this manner. This study was designed to determine the efficacy of SVN treatments when given in-line with high flow oxygen to spontaneously breathing patients. **Methods:** A 2-chamber test lung connected by a metal bar had one side driven by a ventilator to simulate spontaneous breathing parameters of 500 mL tidal volume and 20 breaths per minute. An aerosol mask was adapted to fit a filter connected to the 'patient' chamber of the test lung. Prepared salbutamol sulphate (5mg in 5mL) was nebulized from a SVN connected directly to the aerosol mask using a driving flow of 8 L/min oxygen. The treatment ran until no audible or visible nebulization occurred for 30 seconds. The test was run at the two patient inspiratory flows (40 and 80 L/min) and then repeated with the SVN placed in-line with high flow oxygen sources at 36 and 70 L/min corresponding to FiO_2's of 0.40 and 0.70 respectively. Aerosol was captured by the filter and then analyzed using a spectrophotometer (280 nm). Absorbance was determined using a standard solution of salbutamol sulphate with a concentration of 0.04 mg/mL. **Results:** Mean concentration of salbutamol (±SD) deposited on the filters is recorded in the table below.

Patient inspiratory flow	SVN alone	36 L/min ($FiO_2 = 0.40$)	70 L/min ($FiO_2 = 0.70$)
40 L/min	*1.23±0.01 mg	◆0.37±0.01 mg	◆0.15±0.04 mg
80 L/min	1.13±0.03 mg	▼0.36±0.07 mg	ND

*p < 0.01 vs 80 L/min, ◆ p < 0.0001 vs SVN alone, ▼p < 0.005 vs SVN alone. ND – not done.

Conclusions: High flow oxygen drastically reduces the amount of drug delivered by an in-line SVN to approximately 2%! Therefore, this practice should be abandoned immediately. Alternate therapies could include a SVN with an oxygen reservoir bag or the use of an MDI.

OF-99-174

TREATMENT OF FAILURES OF ENDOSCOPIC SINUS SURGERY WITH NEBULIZED TOPICAL ANTIBIOTICS

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Purpose: To study the efficacy of nebulized topical tobramycin in patients with chronic sinusitis persisting despite adequate endoscopic sinus surgery (ESS).

Study Design: 20 patients with failed ESS were entered in a randomized, double-blinded, placebo controlled trial. Tobramycin or saline solution were administered to the nasal passage via a large particle nebulizer apparatus (RhinoFlow™, Respironics Inc.), for 4 weeks, followed by a 4 week observation period. Symptoms and quality of life (QOL) were assessed by questionnaire. Sinonasal endoscopy assessed mucosal status. Subjects were evaluated at enrollment, initiation of treatment, and 2, 4, and 8 weeks.

Results: Symptoms: In both groups, there was a trend to reduction of pain and post-nasal drip. QOL: In both groups, there was a trend towards improvement in all domains. This was more pronounced at the end of the observation period. Mucosal status: In both groups, edema, secretions, and crusting were significantly reduced following the four week treatment period.

Conclusion: Treatment with four week course of large particle nebulized therapy improves symptomatology and objective parameters of refractory chronic sinusitis. This effect occurs even in the placebo group, suggesting that it is principally due to saline irrigation. Continued improvement beyond the treatment period suggests a lasting effect on the underlying disease process.

Funded by a Grant-in-aid from Respironics/Health Scan Inc.

OF-99-165

DO "ELBOW ADAPTERS" REDUCE AEROSOL DELIVERY TO THE BRONCHI DURING MECHANICAL VENTILATION?

J B Fink, MS, RRT, K.E Fahey, R. Dhand, MD. Div of Pulm and Crit Care Med, Hines VA Hospital, Loyola Stritch School of Med, Hines, IL.

Background: Heated humidity during mechanical ventilation (CMV) reduces aerosol delivery from a metered dose inhaler (MDI). We previously reported less aerosol loss from impaction in the endotracheal tube (ETT) than the ventilator circuit, under both ambient (dry) and humidified conditions (Am J Respir Crit Care Med 1999;159:63-68). The the right angle elbow adapter may be a factor reducing aerosol delivery.

Methods: To determine the effect of an elbow adapter on aerosol delivery, four puffs of albuterol (360µg) were administered from a MDI into an integrated heated-wire circuit with spacer/actuator (Fisher Paykell) during CMV (VT 800 ml, peak flow 40 L/min, rate 12/min), under dry and humidified conditions, with and without an elbow adapter. Delivery of albuterol (% of nominal dose SE) to the bronchi of an intubated (8.0 mm ETT) tracheo-bronchi model was determined.

Results: With the elbow adapter more aerosol was deposited to the bronchi under dry conditions (25.31.1%) than with humidity (19.21.1%; p<0.01). Removing the elbow adapter, albuterol delivery to the bronchi was similar under dry (26.1 0.9 %) and humid (26.30.1%) conditions.

Discussion: Our findings suggest that the elbow adapter reduces aerosol delivery during humid but not dry conditions. Without the elbow adapter there was no difference in aerosol delivery between dry and humidified conditions. Previous reports of reduced delivery of aerosol during CMV with humidity utilized elbow adapters between the ventilator circuit and endotracheal tube. Redesign of the ventilator circuit/ETT interface may result in more efficient aerosol delivery during CMV. Further research is warranted to determine if our findings pertain to other ventilator circuit and MDI spacer configurations.

Conclusion: The elbow adapter did reduce aerosol delivery during CMV under humidified conditions.

OF-99-175

DOES ELECTRO-STATIC CHARGE OF THE MATERIALS IN ENDOTRACHEAL TUBES REDUCE DELIVERY OF AEROSOL DURING MECHANICAL VENTILATION?

J B Fink, MS, RRT, K.E Fahey, R. Dhand, MD. Div of Pulm and Crit Care Med, Hines VA Hospital, Loyola Stritch School of Med, Hines, IL.

Background: Electrostatic charge of some plastics has been shown to reduce aerosol delivery from metered-dose inhalers through spacer devices. The effects of these electrostatic charges were reduced with application of de-ionizing soap solutions such a common dish soap.

Methods: To determine if the electrostatic charge in endotracheal tubes reduces aerosol delivery, four puffs of albuterol (360µg) were administered from a MDI into an integrated heated-wire circuit with spacer/actuator (Fisher Paykel) during CMV (VT 800 ml, peak flow 40 L/min, rate 12/min), under heated/humidified conditions, through 8.0 mm ID endotracheal tubes (Sheridan and Allegiance, n=4) when each tube was: 1) fresh from the package; 2) rinsed with tap water; and 3) washed with de-ionizing soap (Joy). Delivery of albuterol (% of nominal dose SE) to the distal tip of the endotracheal tube was determined.

Results: Aerosol delivery through the endotracheal tube from the package (28.91.6%) and after rinsing with tap water (29.50.35%) were similar. Washing the endotracheal tube with de-ionizing soap resulted in improved aerosol delivery (34.60.46%; p<0.02).

Discussion: Use of a de-ionizing soap (shown to reduce electrostatic charge) significantly improved aerosol delivery in both brands of endotracheal tube tested. Materials with less electrostatic charge in endotracheal tubes may improve aerosol delivery .

Conclusion: Washing endotracheal tubes with de-ionizing dish soap improves aerosol delivery of albuterol from a MDI during mechanical ventilation.

OF-99-176

FIRING A METERED-DOSE INHALER AWAY FROM THE PATIENT REDUCES AEROSOL DELIVERY DURING MECHANICAL VENTILATION

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Background: Several actuator devices for delivering aerosol from metered-dose inhalers (MDI) during mechanical ventilation are designed to direct the ìplumeî of aerosol away from the patient, into the oncoming inspiratory gas flow.

Methods: To determine whether directing the plume from the MDI away from the patient improves aerosol delivery, four puffs of albuterol (360µg) were administered from a MDI containing albuterol (Ventolin, Glaxo) into 6 brands of spacer/actuator (Allegiance Unidirectional, Hudson inline, ACE, OptiVent, MediSpacer, AeroChamber MV) during mechanical ventilation (VT 800 ml, peak flow 40 L/min, rate 12/min), under dry conditions. Each device was placed in the inspiratory limb of the ventilation circuit, with the plume directed toward or away from the patient airway. Delivery of albuterol (% of nominal dose (SE) to the bronchi of an intubated (8.0 mm ETT) tracheo-bronchi model was determined.

Results: Firing the MDI towards the patient improved aerosol delivery to the bronchi with each device tested. Conclusion: During mechanical ventilation, all devices tested delivered more albuterol to the bronchi when the output of the MDI was directed towards the patient. Devices designed to fire the plume away from the patient (ACE, Optivent, Medispacer) were more efficient when directing the MDI output towards the patient.

OF-99-177

COMPARISON OF ABBREVIATED AEROSOL THERAPY USING ALBUTEROL AND IPRATROPIUM BROMIDE WITH A CIRCULAIRE™ NEBULIZER TO CONVENTIONAL SMALL VOLUME NEBULIZER THERAPY.

Daniel G. Walters, M.D., Stanley M. Baldwin, MBA, RRT, Department of Pulmonary Services, Desert Regional Medical Center, Palm Springs, Ca..

Background: Previous studies have demonstrated the superior performance characteristics of the Circulaire™ Nebulizer and that abbreviated and undiluted bronchodilator therapy is as safe an efficacious to a conventional small volume nebulizer. This study compared abbreviated (six minute) aerosol therapy with albuterol and ipratropium bromide using a Circulaire™ nebulizer to non-abbreviated (fifteen minute) aerosol therapy with the same drug mix using a conventional small volume nebulizer for safety and efficacy. Methods: All patients entering our Emergency Department with an increased work of breathing requiring aerosolization of the combination albuterol and ipratropium bromide were randomized to either the abbreviated Circulaire™ treatment or the hospitals' standard nebulizer treatment. The sample was comprised of 60 patients. Variables included pre and post treatment, work of breathing, heart rate, respiratory rate, peak expiratory flow, FEV1, patient's tremulousness and relief of dyspnea. Statistical analysis using t-test compared the groups of the first treatment, and all treatments. Data was also compared using pre treatment variables. Patients response to work of breathing, relief of dyspnea, ease of use, and tremulousness were ranked using a Likert 5 point scale; 1 lowest and 5 highest.

Variable	6 min./Circulaire™ Mean	SVN Mean	P-Value
Pre Treatment	n=30	n=30	
Work of breathing	• 2.73	2.16	.041
Heart rate	96.76	93.83	
Resp. rate	• 25.13	21.80	.060
PEFR l/m	157.90	187.49	
FEV1 liters	1.05	1.13	
First Treatment	n=30	n=30	
pt. noted relief	4.13	4.25	
pt. noted ease of use	• 3.50	4.16	.01
pt. noted tremulousness	2.30	2.01	
Change in heart rate	.17	-1.70	
Change in resp. rate	-1.40	-2.00	
Change in PEFR l/m	22.33	34.50	
Change in FEV1 liters	0.22	0.25	

• Statistically Significant

Results: Both treatments were equally safe and the abbreviated consumed about 9 minutes less and was easier to use by patients. The standard fifteen minute treatment mean change in PEFR was 50% higher, but not statistically significant (P=.228). This could partially be explained by significant increases in work of breathing and respiratory rate of the 6 minute group even with randomization. FEV1 were comparable between both groups.

Conclusion: Abbreviated treatments using albuterol and ipratropium bromide using a Circulaire™ Nebulizer provided comparable bronchodilation with improved efficiency and potential cost savings.

OF-99-186

EXTRA THORACIC VARIABLE AIRWAY OBSTRUCTION DUE TO INHALED STEROID INDUCED MUCOCUTANEOUS CANDIDIASIS

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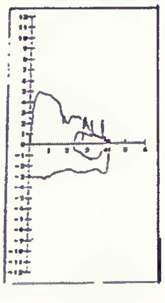
Inhaled Steroids are considered mainstay of Asthma management. Although its benefits outweigh the potential risks and complications there are certain undesired effects. The awareness of these uncommon but occasionally confusing complications is important. The incidence of localized upperairway infection is approximately 2.5%. These infections due to candida albicans may resolve spontaneously or require antifungal therapy. Occasionally, the drug needs to be discontinued. We present two cases of inhaled steroid related mucocutaneous candidiasis causing variable extrathoracic airway obstruction.

A 54-year-old Caucasian man, marathon runner presented with one month history of progressive shortness of breath and hoarseness of voice. He had no other symptoms. Patient's past medical history was remarkable for exercise induced asthma. In general his symptoms were well controlled with inhaled beta agonist and inhaled steroid therapy delivered by meter dose inhalers. He denied any recent respiratory tract infection or any change in his health. A flow-volume loop revealed flattening of the inspiratory limb (fig. 1) consistent with variable extrathoracic airway obstruction. Fiberoptic bronchoscopy showed adhesion of anterior part of vocal cords with inflammatory changes of surrounding mucosa. Cultures were positive for candida albicans.

A 66-year-old Caucasian man presented with episodes of apnea and syncope after severe paroxysmal cough. He had been treated with inhaled steroids for presumptive diagnosis of Asthma for last many weeks. A flow-volume loop revealed flattening of the inspiratory limb consistent with variable extrathoracic airway obstruction. Fiberoptic bronchoscopy showed inflammation of the laryngeal and glottic mucosa. Cultures taken from this area were negative.

In both patients the inhaled steroid therapy was discontinued and oral fluconazole started. Patients' symptoms resolved. The follow up flow-volume loop at the end of the therapy was normal.



(fig. 1)

OF-99-190

COST MINIMIZATION ANALYSIS OF DOSIMETER-CONTROLLED SMALL VOLUME NEBULIZER THERAPY COMPARED TO STANDARD SMALL VOLUME NEBULIZER THERAPY Charles R Hall, Sr, BS, RRT, RPFT, R. Randall Baker, PhD, RRT, RCPT. Medical College of Georgia, Augusta, GA. **BACKGROUND:** Standard small volume nebulizer (stSVN) therapy is still frequently ordered in the hospital. A survey of area hospitals demonstrated an average >50,000 stSVN floor treatments performed yearly. We have demonstrated that dosimeter-controlled small volume nebulization (dcSVN) gives effective bronchodilation with a short treatment time. Thus, use of dcSVN by a Respiratory Care Practitioner may be a cost effective alternative to stSVN. **METHODS:** This study used a cost minimization analysis to compare the direct total costs between dcSVN therapy and stSVN therapy to deliver the drug albuterol. Overhead costs, gas delivery equipment, disposable equipment, and medication for each method were assumed to be equal. Therefore, the unique variables for cost analysis were the aerosol delivery time for each method and the capital costs for the dcSVN equipment. A range (10–15 minutes) of aerosol delivery time for stSVN was obtained from the American Association for Respiratory Care's Uniform Reporting Manual 3rd ed. A previous study revealed less than 2 minutes was necessary to deliver a 180 μg dose of albuterol per dcSVN. Cost savings analysis was performed for a hospital with an average of 50,000 stSVN treatments per year for conversions of 25%, 50%, and 75% to dcSVN therapy. Aerosol dose times for each 180 μg (2 minute) level of the dcSVN method from 4 (360 μg) to 14 minutes (1260 μg) was compared to the stSVN method at 10, 12, and 14 minute treatment time levels. Costs were obtained by using a modest $0.25/minute ($15/hour) salary as a baseline. By demonstrating an increase in the number of treatments/hour/employee for both 8 and 12 hour shifts for dcSVN aerosol delivery over stSVN, evaluation of employee position savings (1 full-time employee = 1.0 FTE) was obtained. **RESULTS:** Conversion cost savings ($) and FTE position savings are represented below. Any FTE position savings could theoretically result in additional employee benefits savings to the institution, thus, increasing overall costs savings. While portable dosimeter systems currently retail for approximately $700 to $1700 per unit, overall costs savings are minimally decreased when comparing dcSVN to the typical 14 minute stSVN. **CONCLUSIONS:** The results suggest that dcSVN may be a cost effective alternative device to consider for precise delivery of bronchodilator medication in the clinical setting. Further studies to validate dcSVN's potential for clinical use are necessary.

dcSVN	stSVN Conversion Savings ($)									FTE Savings	
	25% (12,500 Txs)			50% (25,000 Txs)			75% (37,500 Txs)				
min/μg	10 min	12 min	14 min	10 min	12 min	14 min	10 min	12 min	14 min	8 hr shift	12 hr shift
4/360	18,750	25,000	31,250	37,500	50,000	62,500	56,250	75,000	93,750	1.38	1.43
6/540	12,500	18,750	25,000	25,000	37,500	50,000	37,500	56,250	75,000	0.83	0.89
8/720	6,250	12,500	18,750	12,500	25,000	37,500	18,750	37,500	56,250	0.50	0.54
10/900	--	6,250	12,500	--	12,500	25,000	--	18,750	37,500	0.25	0.31
12/1080	--	--	6,250	--	--	12,500	--	--	18,750	0.08	0.14
14/1260	--	--	--	--	--	--	--	--	--	--	--

OF-99-203

A SURVEY OF ALBUTEROL ADMINISTRATION PRACTICES IN THE NEWBORN ICU. Julie Ballard RRT, BS, John W. Salyer RRT, BS, MBA, FAARC, Janet M Quigley, Ralph A. Lugo PharmD, Primary Children's Medical Center and the University of Utah, Salt Lake City, UT. **Introduction**: The practice of administering Albuterol (ALB) by metered dose inhaler (MDI) is increasing in ventilated neonates. This study was designed to measure some aspects of this practice. **Methods:** A survey instrument was developed that measured 27 aspects of ALB administration. The survey was administered by phone to hospitals with a neonatal fellowship program (*J Pediatr* 1999;134(1):41A-45A). Participation was requested from respiratory therapists or managers having direct knowledge of neonatal clinical practices. Results are reported as percentages and where applicable ± 1 SD. **Results**: Eighty-one hospitals were eligible for participation and there were 68 responses (84% response rate). Responders averaged 35 ± 13 NICU beds and 11 ± 5 ventilators/day. Fifty-seven percent of respondents reported administering ALB by MDI. Table 1 describes the breakdown of ALB MDI usage. The following doses of ALB were reported: average dose 1 puff = 31%, 2 puffs = 64%, 4 puffs = 5%; maximum dose 2 puffs = 31%, 3 puffs = 14%, 4 puffs = 34%, 6 puffs = 11%, 8 puffs = 6%. One hospital reported using up to 40 puffs per treatment. ALB MDI/spacer is placed in-line in 32% of hospitals, hand-bagged in 55% or administered both ways in 13%. In-line spacer placement was reported as follows between ETT and ventilator circuit = 56%, and in the inspiratory limb = 44%. Waiting time between MDI actuations: 20 sec = 6%, 30 sec = 26%, 45 sec = 14%, 60 sec = 46%, 90 sec = 3%, 120 sec = 3%, 180 sec = 3%. When asked whether spacer dead space is of concern, 83% said no. If ALB is administered by nebulizer, placement of the nebulizer is described in Table 2. One hospital reported administering ALB directly down the ETT. **Discussion:** The majority of respondents administer ALB by MDI and average 1-2 actuations per treatment. The most common waiting period is 30-60 sec between actuations and there was little concern about the dead space introduced by spacers. It is noteworthy that 42% of institutions continue to administer ALB by nebulizer despite the inefficiencies of this method. Furthermore, there is a lack of consensus regarding nebulizer placement.

Table 1: MDI Usage

ALB Administered by MDI (%)	Hospitals (%)
100	19
75-99	22
50-74	9
25-49	4
1-24	3
0	43

Table 2: Nebulizer Placement

Nebulizer Placement	Hospitals (%)
Inspir limb near wye	45
Midway down inspir limb	29
Handbagged	12
At humidifier	10
Between ETT & wye	4

OF-99-210

ALBUTEROL DELIVERY IN AN INFANT VENTILATOR-LUNG MODEL: NEBULIZATION VS. MDI/SPACER. Ralph A. Lugo, PharmD, Kathy Poll, RRT, Jim Keenan, BS, RRT, John W. Salyer, RRT, BS, MBA, FAARC, Madolin Witte, MD. University of Utah College of Pharmacy and School of Medicine, Primary Children's Medical Center, Salt Lake City, Utah.

Background: Mechanically ventilated infants with lung disease often receive aerosolized albuterol (ALB). Many institutions deliver ALB via nebulization, however administration by metered dose inhaler (MDI) may be more efficient and less costly. Replacing nebulized ALB with MDI in ventilated infants requires that equivalent doses be determined. This bench study compared ALB delivery via nebulizer and MDI/spacer in an infant ventilator-lung model. The objective was to determine equivalent doses of nebulized ALB and ALB administered by MDI and spacer. Methods: The model consisted of a Bird VIP ventilator in a volume cycled mode with settings to simulate a 5-kg infant with moderate lung disease: V_T 50 mL (10 mL/kg), PIP 30 cm H_2O, rate 15, Ti 0.6 sec, PEEP 4 cm H_2O, FiO_2 0.4, ventilator flow 7 L/min, and gas conditioned to 34° C. The circuit was attached to a 4-mm endotracheal tube (ETT) and a pediatric test lung (Vent Aid® TTL®): compliance = 3.26 mL/cm H_2O and resistance = 142 cm H_2O/L/s. A Sims breathing filter (# 2832) was placed between the ETT and test lung to collect ALB. The nebulized solution consisted of 1.5 mL of ALB (5mg/mL) + 1.5 mL 0.9% NaCl. The solution was nebulized (Airlife® Misty-Neb®) from 2 locations, 135 cm from the ETT and at the circuit wye. ALB MDIs (Ventolin®) were tested under 2 conditions: 1) actuation into an ACE® spacer placed in-line between the circuit wye and the ETT; and 2) actuation into an ACE® spacer attached to the ETT and an anesthesia bag followed by manual ventilation (rate 15, PIP 30 cm H_20). Each MDI experiment was conducted by actuating 10 different ALB canisters twice with 30 sec. between actuations. Five replicates were performed for each experimental condition. Filters were rinsed with 50 mL of 50% methanol solution and ALB concentration were analyzed chromatographically (HPLC) (99.1% accuracy and CV < 3.3%, n=9). Results: Mean (SD) ALB delivery (%) is presented below.

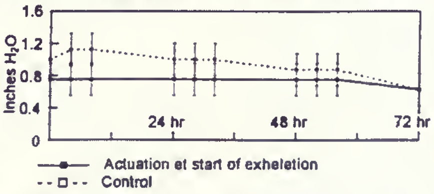
Dosage Form	Method of Administration	% Delivery	ALB Dose	ALB Delivered
ALB 5 mg/mL	Nebulized at wye	1.16 (0.32)	1250 μg	14.5 μg
ALB 5 mg/mL	Nebulized at 135 cm	1.50 (0.17)*	1250 μg	18.8 μg
Ventolin® MDI	In-line ACE® spacer	18.70 (1.77)†	100 μg	18.7 μg
Ventolin® MDI	ACE® + manual ventilation	23.20 (5.42)†	100 μg	23.2 μg

*p=0.06 compared to ALB nebulized at wye (t-test); †p=0.001 compared to both nebulized groups (ANOVA on Ranks with Tukey *post hoc* test). Conclusion: The efficiency of ALB delivery following actuation of Ventolin® MDI into an ACE® spacer was superior to nebulizing ALB solution; however, manual ventilation resulted in significant variability in drug delivery. To determine equivalent doses between nebulized ALB and MDI, percent delivery was multiplied by the ALB dose for each dosage form. In this infant ventilator-lung model, 1 puff of Ventolin® MDI (100 μg) into an in-line ACE® spacer delivers approximately the same amount of aerosolized albuterol as nebulizing 0.25 mL (1250 μg) of albuterol solution (5 mg/mL).

OF-99-209

CAN AN MDI DEVICE AT THE ET TUBE CLOG AN HCH?
Scott Foss BS, Jean Keppel PhD, David Sladek CRTT, Thayer Medical Corporation. Tucson AZ.

Background: Passive humidifiers, such as hygroscopic condenser humidifiers (HCH) have been used increasingly in ventilator circuits since the mid-1980s. Because the HCH is placed between the patient wye and the ET tube, it would need to be removed from the circuit before an MDI drug could be delivered from a location on the inspiratory limb of the circuit. To avoid breaking the circuit for an MDI treatment, it would be desirable to place the MDI device between the HCH and the ET tube, as long as it could be shown that the MDI drug would not clog the HCH even under non-ideal conditions. **Method:** A Bear 1 ventilator (V_T = 700 mL, peak flow = 45 L/min, 6 breaths/min) was attached to a patient wye, which was followed by a Baxter Adult Filtered HCH, then a Thayer dual-spray 15-mm ID/OD MiniSpacer® MDI device, then the ET tube with filter on the end. The filter was followed by a humidifier which exposed the ET tube and HCH to 100% humidity. A test lung was attached to the humidifier by heated-wire tubing kept at 36 ± 1 °C. At the start of each test run, a new HCH was put into the circuit and the air flow resistance across the HCH was measured at peak flow. Two types of tests were run: (a) A 72-hour test, with "worst-case" drug delivery, that is, the MDI was actuated at the start of the lung's exhalation. The circuit was run continuously for 3 days, throughout which 72 doses *each* of Ventolin® (albuterol) and Alupent® (metaproterenol sulfate) were delivered, for a total of 144 actuations. A control was run with the same setup but no drug delivery. The air flow resistance across the HCH was measured periodically in both the control and the test run. (b) Ten sets of 72-minute tests (and controls), with the same two drugs actuated 72 times each, either correctly (at the start of inhalation) or incorrectly (at the start of exhalation or the start of the pause between breaths). For these 10 sets, ANOVA could be run to check the significance of the resistance results.



Results: The graph shows the air flow resistence of the HCH (inches H_2O) measured periodically during the 72-hour test and control. Error bars show the measurement uncertainty in the air flow resistence. Results for the 72-minute tests are not shown here but are similar: In no case did the HCH resistance change. The two-factor ANOVA showed statistical equivalence among all results with time.
Conclusions: MDI drugs delivered at the ET tube are unlikely to clog an HCH, even if the drug is somewhat sticky (like Alupent) and even if the MDI is actuated at the wrong part of the breath cycle. There are other reasons (dose output) to actuate the MDI at the start of inhalation, and there are other substances (secretions) that may clog an HCH, but the MDI drug is not implicated as a clogging agent even in the "worst case."

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Congress Exhibitors

Exhibitors

at the 45th International Respiratory Congress
of the American Association for Respiratory Care

December 13-16, 1999
Las Vegas, Nevada

Thousands of examples of respiratory care equipment and supplies are displayed, discussed, and demonstrated in the exhibit booths at the International Respiratory Congress. The AARC thanks the firms that support the Association by participating. (Exhibitors confirmed by September 2, 1999 are listed.)

Exhibit Hours

Monday, December 13	11 AM to 4 PM
Tuesday, December 14	11 AM to 4 PM
Wednesday, December 15	11 AM to 4 PM
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Notices

Notices of competitions, scholarships, fellowships, examination dates, new educational programs, and the like will be listed here free of charge. Items for the Notices section must reach the Journal 60 days before the desired month of publication (January 1 for the March issue, February 1 for the April issue, etc). Include all pertinent information and mail notices to RESPIRATORY CARE Notices Dept, 11030 Ables Lane, Dallas TX 75229-4593.

Las Vegas

45TH INTERNATIONAL
RESPIRATORY CONGRESS
DECEMBER 13–16, 1999
LAS VEGAS, NEVADA

1999

Helpful Web Sites

American Association for Respiratory Care
http://www.aarc.org
- Current job listings
- American Respiratory Care Foundation fellowships, grants, & awards
- Clinical Practice Guidelines

National Board for Respiratory Care
http://www.nbrc.org

RESPIRATORY CARE online
http://www.rcjournal.com
- 1997 Subject and Author Indexes
- Contact the editorial staff

Asthma Management Model System
http://www.nhlbi.nih.gov

Keys to Professional Excellence
http://www.aarc.org/keys/

RC Week Online
http://www.aarc.org/rcweek/

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LOOK FOR

OPEN FORUM ABSTRACTS

THIS ISSUE

Not-for-profit organizations are offered a free advertisement of up to eight lines to appear, on a space-available basis, in Calendar of Events in RESPIRATORY CARE. Ads for other meetings are priced at $5.50 per line and require an insertion order. Deadline is the 20th of the month two months preceding the month in which you wish the ad to run. Submit copy and insertion orders to Calendar of Events, RESPIRATORY CARE, 11030 Ables Lane, Dallas TX 75229-4593.

Calendar of Events

AARC & AFFILIATES

October 1—*Melville, New York*
The NYSSRC's Southeastern Chapter hosts their 31st annual symposium, "Respiratory Care — A Work in Progress," at the Huntington Hilton Hotel in Melville, Long Island. The keynote address will be given by Carl Wiezalis, vice-president of the AARC.
Contact: For information, call Jim Ganetis at (516) 444-3181 or **www.nyssrc.org**.

October 6–8—*Louisville, Kentucky*
The Kentucky Society for Respiratory Care presents Cruise into the Next Millennium — its annual convention and vendor exhibition — at the Galt House East. Program topics include critical care, management, pediatric, and Year 2000 issues. CRCE credits are available.
Contact: Mitzi Thomason at (502) 897-8884.

October 19—*Live Videoconference*
Participate in a live, 90-minute satellite broadcast of the eighth installment of the AARC's 1999 "Professor's Rounds" series and receive one CRCE credit hour. "New Developments in Respiratory Drugs, Medications, and Delivery Devices" will be broadcast from 11:30–1 p.m. (CT).
Contact: For more information, call the AARC at (972) 243-2272.

October 20–22—*Daniels, West Virginia*
The West Virginia Society for Respiratory Care will host its Annual Fall Meeting at the Glade Springs Resort, Country Inns and Suites.
Contact: For more information, contact Jay Wildt, co-chair of program and education, at (304) 442-7474.

October 26—*Teleconference*
After viewing a tape of the seventh installment of the AARC's 1999 "Professor's Rounds" series, "PEEP: The State of the Art," participate in a live telephone question-and-answer session (11:30–12 noon CT) and receive one CRCE credit hour.
Contact: To receive the 90-minute videotape and register for the teleconference, call the AARC at (972) 243-2272.

November 16—*Teleconference*
After viewing a tape of the eighth installment of the AARC's 1999 "Professor's Rounds" series, "New Developments in Respiratory Drugs, Medications, and Delivery Devices," participate in a live telephone question-and-answer session (11:30–12 noon CT) and receive one CRCE credit hour.
Contact: To receive the 90-minute videotape and register for the teleconference, call the AARC at (972) 243-2272.

December 13–16—*Las Vegas, Nevada*
The AARC's 45th International Respiratory Congress is scheduled for Dec. 13–16 (Monday through Thursday) at the Las Vegas Convention Center. Sessions appealing to all levels of health care providers will be offered, with CRCE credit available. Exhibits by international manufacturers of cardiopulmonary equipment will be featured. Additional information will be available in the fall.

Other Meetings

October 1–3—*Ottawa, Ontario, Canada*
The Canadian COPD Alliance will host "Building and Enriching Partnerships in the Management of COPD" at the Radisson Hotel Ottawa Centre. This conference will include plenary sessions on the epidemiology of COPD and scientific workshops on spirometry, smoking cessation, and the evidence to support management approaches to COPD. Included is a series of practical workshops on rehabilitation and a parallel consumer track for those who live with COPD.
Contact: call (613) 747-6776 or see their web site at **www.lung.ca/CCA/conference**.

October 4–5—*Ann Arbor, Michigan*
The Office of Continuing Medical Education at the University of Michigan is sponsoring a conference, "Update on Pulmonary and Critical Care Medicine," at the Towsley Center.
Contact: For more information, contact Laura Castellanos at (734) 647-8784.

October 28–30—*Toronto, Ontario, Canada*
The Critical Care Medicine Programme of the University of Toronto will present the Toronto Adult and Paediatric Critical Care Medicine Symposium at the University of Toronto in Ontario, Canada.
Contact: For information contact Ms. K. Boyko, 555 University Ave., Toronto, Ontario, Canada M5G 1X8; (416) 813-6477; fax (416) 813-5094; tccm@sickkids.on.ca.

October 31–November 4—*Chicago, Illinois*
The American College of Chest Physicians will host their 65th Annual International Scientific Assembly at the Lakeside Center. For information, contact Member Services at (800) 343-2227, fax (847) 498-5460, or **www.chestnet.org**.

MEDWATCH

THE FDA MEDICAL PRODUCTS REPORTING PROGRAM

For VOLUNTARY reporting
by health professionals of adverse
events and product problems

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Triage unit
sequence #

A. Patient information

1. **Patient identifier**
In confidence

2. **Age at time of event:**
or ________
Date of birth:

3. **Sex**
☐ female
☐ male

4. **Weight**
____ lbs
or
____ kgs

B. Adverse event or product problem

1. ☐ **Adverse event** and/or ☐ **Product problem** (e.g., defects/malfunctions)

2. **Outcomes attributed to adverse event**
(check all that apply)
☐ death ________ (mo/day/yr)
☐ life-threatening
☐ hospitalization – initial or prolonged
☐ disability
☐ congenital anomaly
☐ required intervention to prevent permanent impairment/damage
☐ other: ________

3. **Date of event** (mo/day/yr)

4. **Date of this report** (mo/day/yr)

5. **Describe event or problem**

Relevant tests/laboratory data, including dates

Other relevant history, including preexisting medical conditions (e.g., allergies, race, pregnancy, smoking and alcohol use, hepatic/renal dysfunction, etc.)

C. Suspect medication(s)

1. **Name** (give labeled strength & mfr/labeler, if known)
#1 ________
#2

2. **Dose, frequency & route used**
#1 ________
#2

3. **Therapy dates** (if unknown, give duration)
from/to (or best estimate)
#1 ________
#2

4. **Diagnosis for use** (indication)
#1 ________
#2

5. **Event abated after use stopped or dose reduced**
#1 ☐ yes ☐ no ☐ doesn't apply
#2 ☐ yes ☐ no ☐ doesn't apply

6. **Lot #** (if known)
#1 ________
#2

7. **Exp. date** (if known)
#1 ________
#2

8. **Event reappeared after reintroduction**
#1 ☐ yes ☐ no ☐ doesn't apply
#2 ☐ yes ☐ no ☐ doesn't apply

9. **NDC #** (for product problems only)
– –

10. **Concomitant medical products** and therapy dates (exclude treatment of event)

D. Suspect medical device

1. **Brand name**

2. **Type of device**

3. **Manufacturer name & address**

4. **Operator of device**
☐ health professional
☐ lay user/patient
☐ other: ________

5. **Expiration date** (mo/day/yr)

6.
model # ________
catalog # ________
serial # ________
lot # ________
other #

7. **If implanted, give date** (mo/day/yr)

8. **If explanted, give date** (mo/day/yr)

9. **Device available for evaluation?** (Do not send to FDA)
☐ yes ☐ no ☐ returned to manufacturer on ________ (mo/day/yr)

10. **Concomitant medical products** and therapy dates (exclude treatment of event)

E. Reporter (see confidentiality section on back)

1. **Name & address**
phone #

2. **Health professional?**
☐ yes ☐ no

3. **Occupation**

4. **Also reported to**
☐ manufacturer
☐ user facility
☐ distributor

5. **If you do NOT want your identity disclosed to the manufacturer, place an " X " in this box.** ☐

FDA

Mail to:
MEDWATCH
5600 Fishers Lane
Rockville, MD 20852-9787

or **FAX to:**
1-800-FDA-0178

IA Form 3500 1/96)

Submission of a report does not constitute an admission that medical personnel or the product caused or contributed to t

ADVICE ABOUT VOLUNTARY REPORTING

Report experiences with:

- medications (drugs or biologics)
- medical devices (including in-vitro diagnostics)
- special nutritional products (dietary supplements, medical foods, infant formulas)
- other products regulated by FDA

Report SERIOUS adverse events. An event is serious when the patient outcome is:

- death
- life-threatening (real risk of dying)
- hospitalization (initial or prolonged)
- disability (significant, persistent or permanent)
- congenital anomaly
- required intervention to prevent permanent impairment or damage

Report even if:

- you're not certain the product caused the event
- you don't have all the details

Report product problems – quality, performance or safety concerns such as:

- suspected contamination
- questionable stability
- defective components
- poor packaging or labeling
- therapeutic failures

How to report:

- just fill in the sections that apply to your report
- use section C for all products except medical devices
- attach additional blank pages if needed
- use a separate form for each patient
- report either to FDA or the manufacturer (or both)

Important numbers:

1-800-FDA-0178	to FAX report
1-800-FDA-7737	to report by modem
1-800-FDA-1088	to report by phone or for more information
1-800-822-7967	for a VAERS form for vaccines

If your report involves a serious adverse event with a device and it occurred in a facility outside a doctor's office, that facility may be legally required to report to FDA and/or the manufacturer. Please notify the person in that facility who would handle such reporting.

Confidentiality: The patient's identity is held in strict confidence by FDA and protected to the fullest extent of the law. The reporter's identity, including the identity of a self-reporter, may be shared with the manufacturer unless requested otherwise. However, FDA will not disclose the reporter's identity in response to a request from the public, pursuant to the Freedom of Information Act.

The public reporting burden for this collection of information has been estimated to average 30 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to:

DHHS Reports Clearance Office
Paperwork Reduction Project (0910-0291)
Hubert H. Humphrey Building, Room 531-H
200 Independence Avenue, S.W.
Washington, DC 20201

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Public Health Service • Food and Drug Administration

FDA Form 3500-back

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Food and Drug Administration
Rockville, MD 20857

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The FDA Medical Products Reporting Program
Food and Drug Administration
5600 Fishers Lane
Rockville, MD 20852-9787

American Association for Respiratory Care

MEMBERSHIP APPLICATION

Please read the eligibility requirements for each of the classifications in the right-hand column, then complete the applicable section. All information requested below must be provided, except where indicated as optional. See other side for more information and fee schedule. Please sign and date application on reverse side and type or print clearly. Processing of application takes approximately 15 days.

- ☐ Active
- Associate
  - ☐ Foreign
  - ☐ Physician
  - ☐ Industrial
- ☐ Special
- ☐ Student

Last Name ______________________________

First Name ______________________________

Social Security No. ______________________________

Home Address ______________________________

City ______________________________

State ____________ Zip __ __ __ __ __—__ __ __ __

Phone No. (______) ______________________________

Primary Job Responsibility (check one only)

- ☐ Technical Director
- ☐ Assistant Technical Director
- ☐ Pulmonary Function Specialist
- ☐ Instructor/Educator
- ☐ Supervisor
- ☐ Staff Therapist
- ☐ Staff Technician
- ☐ Rehabilitation/Home Care
- ☐ Medical Director
- ☐ Sales
- ☐ Student
- ☐ Other, specify ______________________

Type of Business

- ☐ Hospital
- ☐ Skilled Nursing Facility
- ☐ DME/HME
- ☐ Home Health Agency
- ☐ Educational Institution
- ☐ Manufacturer or supplier
- ☐ Other, specify ______________________

Date of Birth (optional) ______________ Sex (optional) __________

U.S. Citizen? ____ Yes ____ No

Have you ever been a member of the AARC? ______________

If so, when? From ______________ to ______________

Preferred mailing address: ☐ Home ☐ Business

For office use only

FOR ACTIVE MEMBER

An individual is eligible if he/she lives in the U.S. or its territories or was an Active Member prior to moving outside its borders or territories, and meets ONE of the following criteria: (1) is legally credentialed as a respiratory care professional if employed in a state that mandates such, OR (2) is a graduate of an accredited educational program in respiratory care, OR (3) holds a credential issued by the NBRC. An individual who is an AARC Active Member in good standing on December 8, 1994, will continue as such provided his/her membership remains in good standing.

PLEASE USE THE ADDRESS OF THE LOCATION WHERE YOU PERFORM YOUR JOB, NOT THE CORPORATE HEADQUARTERS IF IT IS LOCATED ELSEWHERE.

Place of Employment ______________________________

Address ______________________________

City ______________________________

State ____________ Zip __ __ __ __ __-__ __ __ __

Phone No. (______) ______________________________

Medical Director/Medical Sponsor ______________________________

FOR ASSOCIATE OR SPECIAL MEMBER

Individuals who hold a position related to respiratory care but do not meet the requirements of Active Member shall be Associate Members. They have all the rights and benefits of the Association except to hold office, vote, or serve as chair of a standing committee. The following subclasses of Associate Membership are available: Foreign, Physician, and Industrial (individuals whose primary occupation is directly or indirectly devoted to the manufacture, sale, or distribution of respiratory care equipment or supplies). Special Members are those not working in a respiratory care-related field.

PLEASE USE THE ADDRESS OF THE LOCATION WHERE YOU PERFORM YOUR JOB, NOT THE CORPORATE HEADQUARTERS IF IT IS LOCATED ELSEWHERE.

Place of Employment ______________________________

Address ______________________________

City ______________________________

State ____________ Zip __ __ __ __ __-__ __ __ __

Phone No. (______) ______________________________

FOR STUDENT MEMBER

Individuals will be classified as Student Members if they meet all the requirements for Associate Membership and are enrolled in an educational program in respiratory care accredited by, or in the process of seeking accreditation from, an AARC-recognized agency.

SPECIAL NOTICE — Student Members do not receive Continuing Respiratory Care Education (CRCE) transcripts. Upon completion of your respiratory care education, continuing education credits may be pursued upon your reclassification to Active or Associate Member.

School/RC Program ______________________________

Address ______________________________

City ______________________________

State ____________ Zip __ __ __ __ __-__ __ __ __

Phone No. (______) ______________________________

Length of program

- ☐ 1 year
- ☐ 2 years
- ☐ 4 years
- ☐ Other, specify ______________

Expected Date of Graduation *(REQUIRED INFORMATION)*

Month ________ Year ________

American Association for Respiratory Care • 11030 Ables Lane • Dallas, TX 75229-4593 • [972] 243-2272 • Fax [972]

American Association for Respiratory Care MEMBERSHIP APPLICATION

Demographic Questions

We request that you answer these questions in order to help us design services and programs to meet your needs.

Check the Highest Degree Earned

- ☐ High School
- ☐ RC Graduate Technician
- ☐ Associate Degree
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctorate Degree

Number of Years in Respiratory Care

- ☐ 0-2 years
- ☐ 3-5 years
- ☐ 6-10 years
- ☐ 11-15 Years
- ☐ 16 years or more

Job Status

- ☐ Full Time
- ☐ Part Time

Credentials

- ☐ RRT
- ☐ CRT
- ☐ Physician
- ☐ CRNA
- ☐ RN
- ☐ LVN/LPN
- ☐ CPFT
- ☐ RPFT
- ☐ Perinatal/Pediatric

Salary

- ☐ Less than $10,000
- ☐ $10,001-$20,000
- ☐ $20,001-$30,000
- ☐ $30,001-$40,000
- ☐ $40,000 or more

PLEASE SIGN

I hereby apply for membership in the American Association for Respiratory Care and have enclosed my dues. If approved for membership in the AARC, I will abide by its bylaws and professional code of ethics. I authorize investigation of all statements contained herein and understand that misrepresentations or omissions of facts called for is cause for rejection or expulsion.

A yearly subscription to RESPIRATORY CARE journal and *AARC Times* magazine includes an allocation of $11.50 from my dues for each of these publications.

NOTE: Contributions or gifts to the AARC are not tax deductible as charitable contributions for income tax purposes. However, they may be tax deductible as ordinary and necessary business expenses subject to restrictions imposed as a result of association lobbying activities. The AARC estimates that the nondeductible portion of your dues — the portion which is allocable to lobbying — is 26%.

Signature ______________________________

Date ______________________________

Membership Fees

Payment must accompany your application to the AARC. Fees are for 12 months. (NOTE: Renewal fees are $75.00 Active, Associate-Industrial or Associate-Physician, or Special status; $90.00 for Associate-Foreign status; and $45.00 for Student status).

☐ Active	$ 87.50
☐ Associate (Industrial or Physician)	$ 87.50
☐ Associate (Foreign)	$102.50
☐ Special	$ 87.50
☐ Student	$ 45.00
TOTAL	$________

Specialty Sections

Established to recognize the specialty areas of respiratory care, these sections publish a bi-monthly newsletter that focuses on issues of specific concern to that specialty. The sections also design the specialty programming at the national AARC meetings.

☐ Adult Acute Care Section	$15.00
☐ Education Section	$20.00
☐ Perinatal-Pediatric Section	$15.00
☐ Diagnostics Section	$15.00
☐ Continuing Care-Rehabilitation Section	$15.00
☐ Management Section	$20.00
☐ Transport Section	$15.00
☐ Home Care Section	$15.00
☐ Subacute Care Section	$15.00
TOTAL	$________

GRAND TOTAL = Membership Fee plus optional sections $________

- ☐ Total Amount Enclosed/Charged $______________
- ☐ Please charge my dues (see below)

To charge your dues, complete the following:

- ☐ MasterCard
- ☐ Visa

Card Number

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Card Expires ______/______

Signature ______________________________

Mail application and appropriate fees to:

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RESPIRATORY CARE

Manuscript Preparation Guide

General Information

RESPIRATORY CARE welcomes original manuscripts related to the science and technology of respiratory care and prepared according to these Instructions and the *Uniform Requirements for Manuscripts Submitted to Biomedical Journals* [Respir Care 1997; 42(6):623-634]. Manuscripts are blinded and reviewed by professionals who are experts in their fields. Authors are responsible for all aspects of the manuscript and receive galleys to proofread before publication. Each accepted manuscript is copyedited so that its message is clear and it conforms to the Journal's style. Published papers are copyrighted by Daedalus Inc and may not be published elsewhere without permission.

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Publication Categories & Structure

Research Article: A report of an original investigation (a study). It includes a Title Page, Abstract, Introduction, Methods, Results, Discussion, Conclusions, Product Sources, Acknowledgments, References, Tables, Appendices, Figures, and Figure Captions.

Evaluation of Device/Method/Technique: A description and evaluation of an old or new device, method, technique, or modification. It has a Title Page, Abstract, Introduction, Description of Device/Method/Technique, Evaluation Methods, Evaluation Results, Discussion, Conclusions, Product Sources, Acknowledgments, References, Tables, Appendices, Figures, and Figure Captions. Comparative cost data should be included wherever possible.

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Review Article: A comprehensive, critical review of the literature and state-of-the-art summary of a pertinent topic that has been the subject of at least 40 published research articles. Title Page, Outline, Introduction, Review of the Literature, Summary, Acknowledgments, References. Tables, Appendices, and Figures and Captions may be included.

Overview: A critical review of a pertinent topic that has fewer than 40 published research articles.

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Point-of-View Paper: A paper expressing personal but substantiated opinions on a pertinent topic. Title Page, Text, References, Tables, and Illustrations may be included.

Special Article: A pertinent paper not fitting one of the foregoing categories may be acceptable as a Special Article. Consult with the Editor before writing or submitting such a paper.

Editorial: A paper drawing attention to a pertinent concern; it may present an opposing opinion, clarify a position, or bring a problem into focus.

Letter: A signed communication, marked "For publication," about prior publications in this Journal or about other pertinent topics. Tables and illustrations may be included.

Blood Gas Corner: A brief, instructive case report involving blood gas values—with Questions, Answers, and Discussion.

Drug Capsule: A mini-review paper about a drug or class of drugs that includes discussions of pharmacology, pharmacokinetics, and pharmacotherapy.

Graphics Corner: A brief case report incorporating waveforms for monitoring or diagnosis—with Questions, Answers, and Discussion.

Kittredge's Corner: A brief description of the operation of respiratory care equipment—with information from manufacturers and editorial comments and suggestions.

PFT Corner: Like Blood Gas Corner, but involving pulmonary function tests.

Cardiorespiratory Interactions. A case report demonstrating the interaction between the cardiovascular and respiratory systems. It should be a patient-care scenario; however, the case—the central theme—is the systems interaction. CRI is characterized by figures, equations, and a glossary. See the March 1996 Issue of RESPIRATORY CARE for more detail.

Test Your Radiologic Skill: Like Blood Gas Corner, but involving pulmonary medicine radiography and including one or more radiographs; may involve imaging techniques other than conventional chest radiography.

Review of Book, Film, Tape, or Software: A balanced, critical review of a recent release.

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Print on one side of white bond paper, 8.5 in. x 11 in. (216 x 279 mm) with margins of at least 1 in. (25 mm) on all sides of the page. Use ***double-spacing*** throughout the ***entire*** manuscript. Use a standard font (eg, Times, Helvetica, or Courier) at least 10 points in size, and do not use italics except for special emphasis. Number all pages in upper-right corners. Indent paragraphs 5 spaces. Do ***not justify***. **Do *not* put authors' names, institutional affiliations or allusions to institutional affiliations in the text, or other identification anywhere except on the title page.** Repeat title only (no authors) on the abstract page. Begin each of the following on a new page: Title Page, Abstract, Text, Product Sources List, Acknowledgments, References, each Table, and each Appendix. Use standard English in the first person and active voice.

Center main section headings on the page and type them in capital and small letters (eg, Introduction, Methods, Results, Discussion). Begin subheadings at the left margin and type them in capital and small letters (eg, Patients, Equipment, Statistical Analysis).

References. Cite only published works as references. Manuscripts accepted but not yet published may be cited as references: designate the accepting journal, followed by (in press), and provide 3 copies of the in-press article for reviewer inspection. Cite references in the text with superscript numerals. Assign numbers in the order that references are first cited. On the reference page, list the cited works in numerical order. Follow the Journal's style for references. Abbreviate journal names as in *Index Medicus*. List all authors.

Article in a journal carrying pagination throughout volume:

> Rau JL, Harwood RJ. Comparison of nebulizer delivery methods through a neonatal endotracheal tube: a bench study. Respir Care 1992;37(11):1233-1240.

Article in a publication that numbers each issue beginning with Page 1:

> Bunch D. Establishing a national database for home care. AARC Times 1991;15(Mar):61,62,64.

Corporate author journal article:

> American Association for Respiratory Care. Criteria for establishing units for chronic ventilator-dependent patients in hospitals. Respir Care 1988;33(11):1044-1046.

Article in journal supplement: (Journals differ in their methods of numbering and identifying supplements. Supply sufficient information to promote retrieval.)

> Reynolds HY. Idiopathic interstitial pulmonary fibrosis. Chest 1986; 89(3 Suppl):139S-143S.

Abstract in journal: (Abstracts citations are to be avoided. Those more than 3 years old should not be cited.)

> Stevens DP. Scavenging ribavirin from an oxygen hood to reduce environmental exposure (abstract). Respir Care 1990;35(11): 1087-1088.

Editorial in journal:

> Enright P. Can we relax during spirometry? (editorial). Am Rev Respir Dis 1993;148(2):274.

Editorial with no author given:

> Negative-pressure ventilation for chronic obstructive pulmonary disease (editorial). Lancet 1992;340(8833):1440-1441.

Letter in journal:

> Aelony Y. Ethnic norms for pulmonary function tests (letter). Chest 1991;99(4):1051.

Paper accepted but not yet published:

> Hess D. New therapies for asthma. Respir Care (year, in press).

Personal author book: (For any book, specific pages should be cited whenever possible.)

> DeRemee RA. Clinical profiles of diffuse interstitial pulmonary disease. New York: Futura; 1990. p. 76-85.

Corporate author book:

> American Medical Association Department of Drugs. AMA drug evaluations, 3rd ed. Littleton CO: Publishing Sciences Group; 1977.

Chapter in book with editor(s):

> Pierce AK. Acute respiratory failure. In: Guenter CA, Welch MH, editors. Pulmonary medicine. Philadelphia: JB Lippincott; 1977:26-42.

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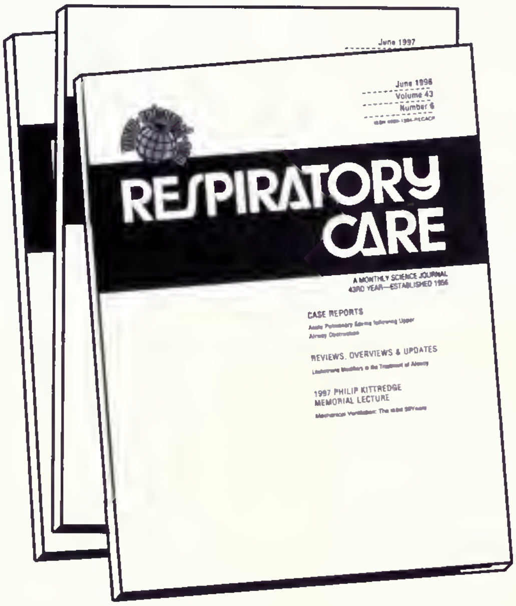

CRCE through the Journal—1999

Answer Key

For your information, the correct answers to the 50 question for *CRCE through the Journal,* which appeared in the August 1999 issue of RESPIRATORY CARE, are given below. No scores will be available from the AARC until 1999 transcripts are released in early 2000. Deadline for submission of answer sheets for CRCE credit was September 30, 1999.

1.	e	11.	a	21.	d	31.	a	41.	c
2.	b	12.	e	22.	c	32.	c	42.	b
3.	e	13.	a	23.	e	33.	e	43.	b
4.	c	14.	b	24.	b	34.	b	44.	d
5.	a	15.	c	25.	e	35.	c	45.	e
6.	c	16.	a	26.	b	36.	d	46.	a
7.	c	17.	d	27.	d	37.	b	47.	e
8.	a	18.	e	28.	a	38.	b	48.	d
9.	c	19.	b	29.	b	39.	e	49.	b
10.	e	20.	a	30.	a	40.	c	50.	d

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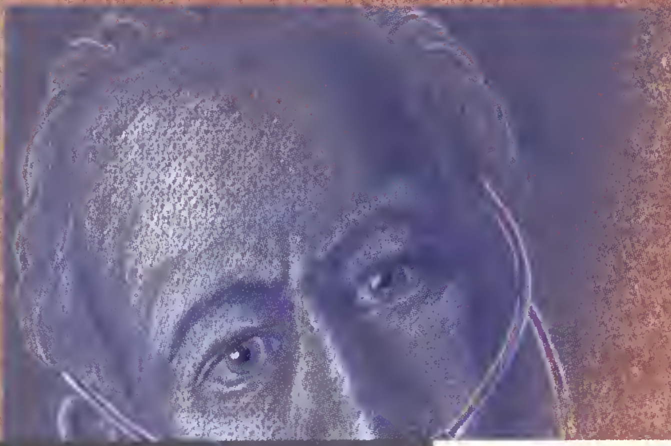

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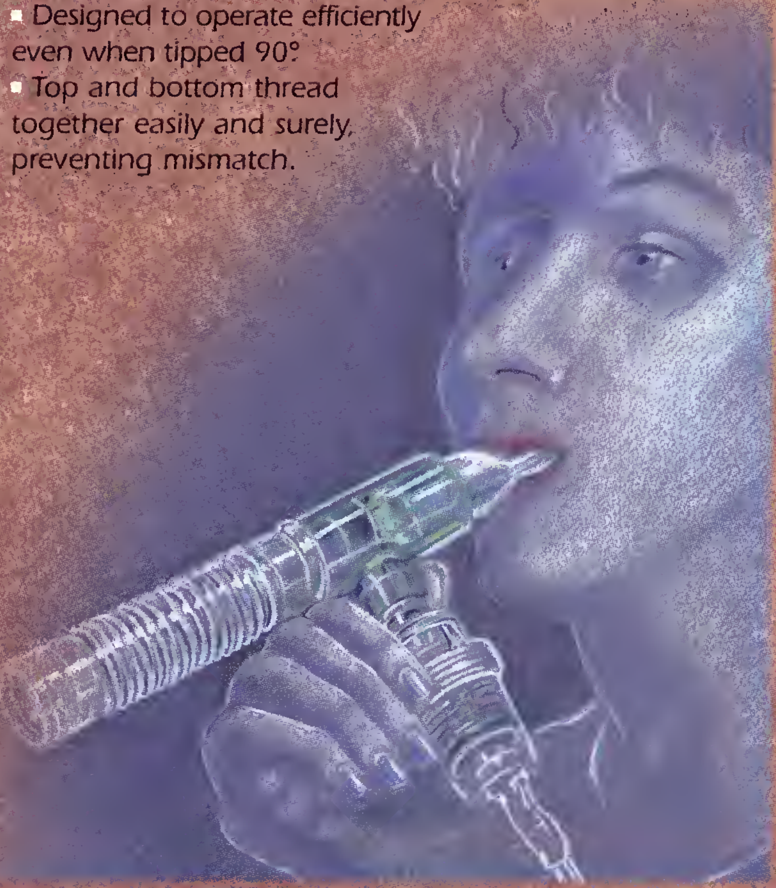

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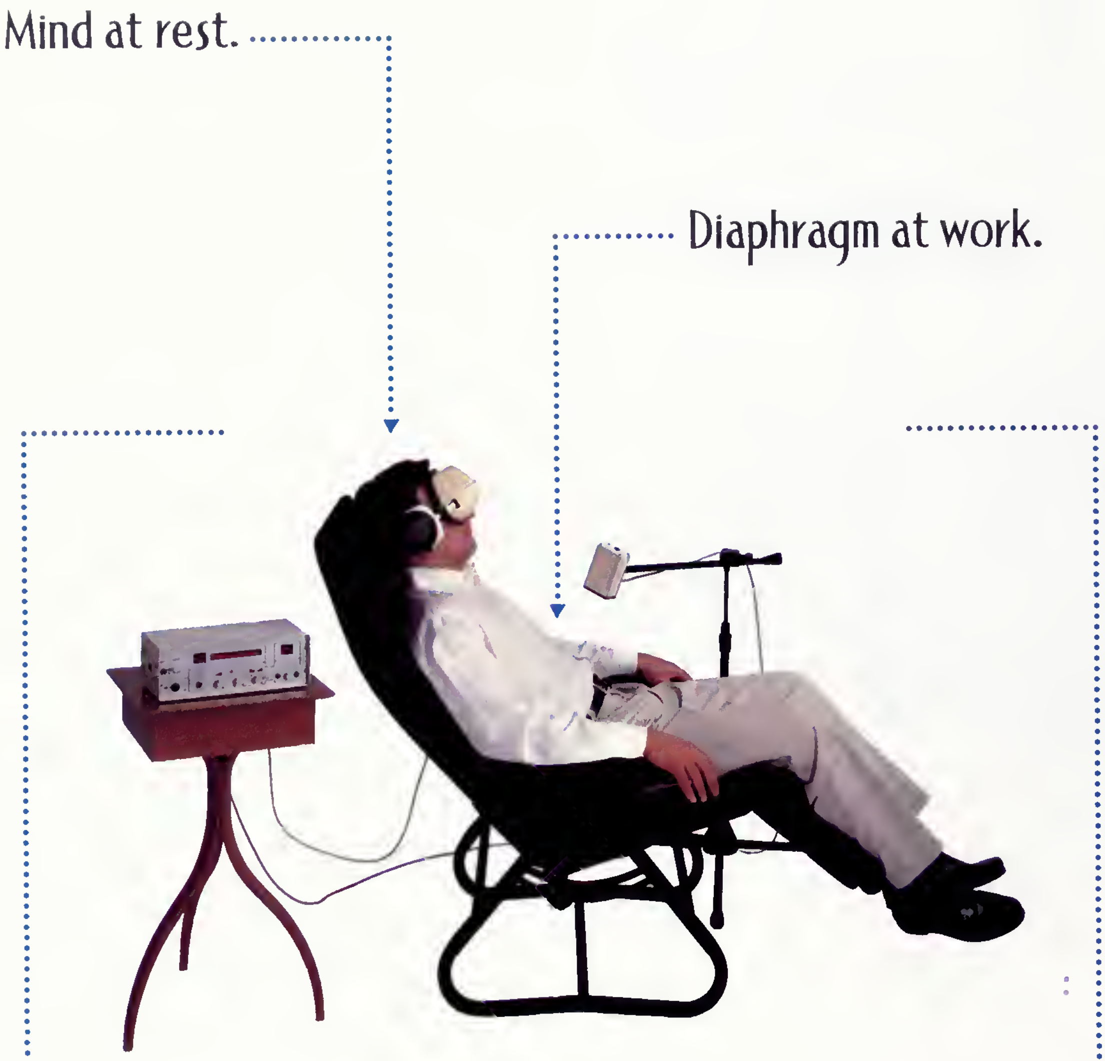

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